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A charge, which will not be returned, will be made of 20s. for each copy of the Specification.

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A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1.
7th September, 1921. S 13

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STOKENCHURCH WATER SUPPLY.
TO BORING CONTRACTORS.

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Tenders endorsed "Stokenchurch Bore Hole," should be addressed to the Undersigned, on or before Thursday, the 29th September, 1921.

The Council do not bind themselves to accept the lowest or any Tender.

B. L. REYNOLDS,
Clerk to the Council.

High Wycombe,
Bucks. R 993

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2.	Wheels and Axles	£1.
3.	Copper Rods and Ingots	£1.
4.	Brass Shoots, Copper Tubes, &c. ...	10s.
5.	Firebricks and Fireclay	10s.

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The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Roofwork (Island Platform Roofing—Nagpur)," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 20th September, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 7th September, 1921. S 3

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND).

CONTRACTS 1921.

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Do. do. for Gas ...	26B	Mats, Fibre	10
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Colours	2	Sewer Pipes, Plaster, etc.	32
Corks	39	Shovels, Spades, etc.	21A
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Grates, Stoves and Fenders	24	Wire, Fence and Signal	30A
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Patterns may be inspected at the General Stores Department on and after the 9th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before Ten a.m. on Wednesday, 21st September, 1921.

The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

By Order,
ROBERT CRAWFORD, Secretary.

Kingsbridge Terminus, Dublin,
September, 1921. R 974

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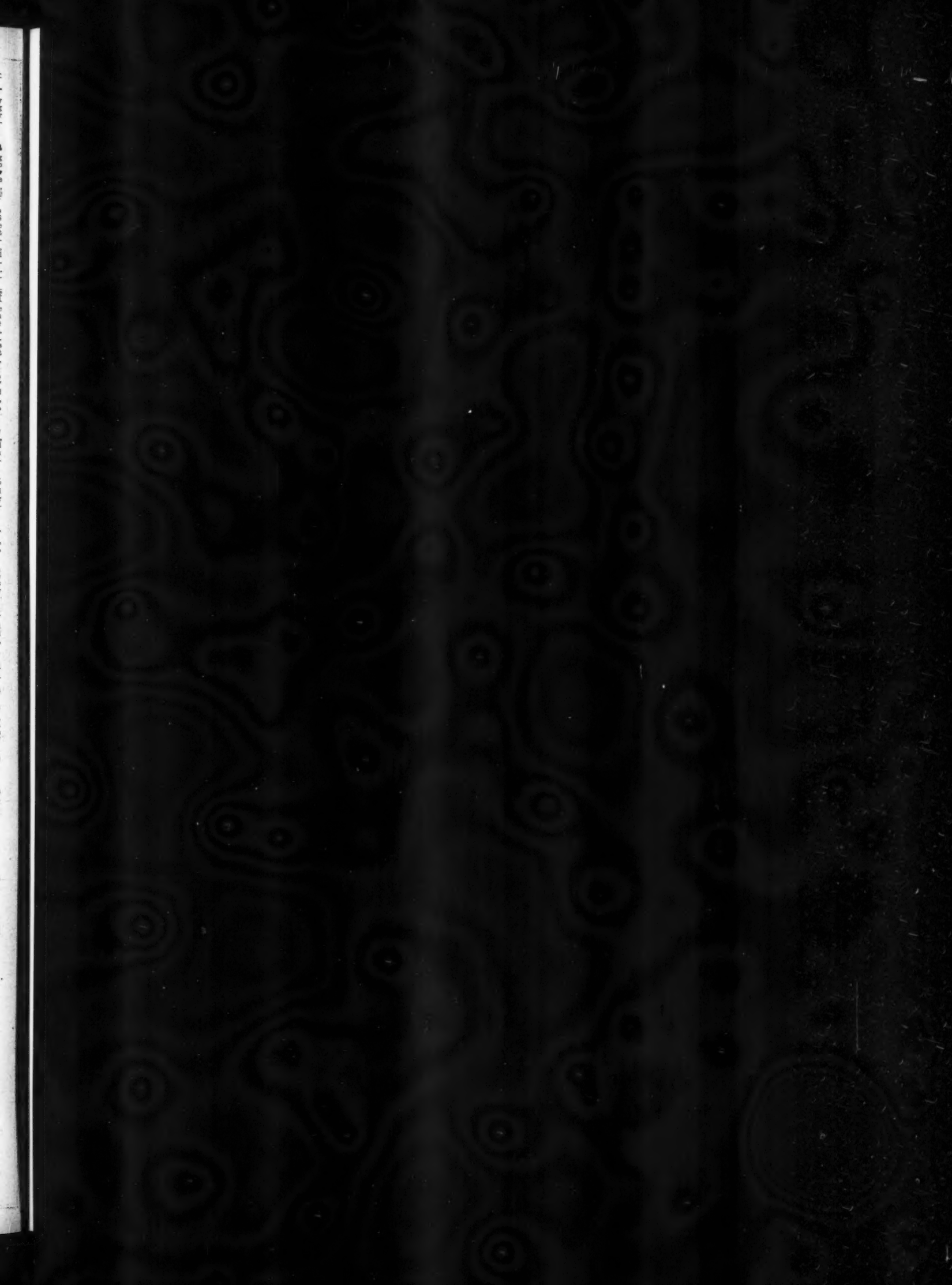


PROGRESS IN GAS MAKING.

It is claimed to be established by observation that even now the domestic hearth is responsible for at least two-thirds of the air pollution in the metropolitan area. Thirty years ago the proportion must have been much larger, if one may judge from the diminution in the virulence of the London "particular" which has often been commented on of late years. This improvement has been commonly attributed to the extent to which the gas stove and the gas cooker have replaced the open fire and the kichen range. Nevertheless gas is not a cheap domestic fuel, and owes its comparative popularity to its great convenience. As matters stand to-day prices have soared nearly to what they were in the early forties of the last century, when 6s. per thousand cubic feet was considered a reasonable figure, as no doubt it appeared to those who remembered that in 1817 the rate was about 14s. a thousand. Owing to the competition of the electricity supply companies, which have taken from the gas works much of the lighting which would otherwise have fallen to them, the gas companies have for many years past been studying ways and means of cheapening their product. It was early recognised that by decreasing the quality of the gas a much larger proportion of the raw coal could be gasified. The almost universal use of the mantle has made it possible to replace the old standard for lighting gas by one based on the calorific value, and as a consequence gas with a calorific value of some 400 B.Th.U. to 450 B.Th.U. per cubic foot, is now a saleable commodity, whereas in the old days the calorific value was commonly nearer 600 than 500 B.Th.U. per cub. foot.

One method of obtaining a larger proportion of coal in the form of saleable gas has been to add water gas to retort gas, the water gas being produced in a separate generator. It was later on found that similar results could be secured by passing steam directly into the retorts, thus dispensing with the separate generator, but with horizontal retorts this procedure had the drawback of reducing the life of the retort. With the new vertical retorts, which came into favour in the first place because they could be operated continuously in place of intermittently, very successful results have been obtained, and as shown by experiments at Macclesfield and at Uddingston, the gain is a very substantial one.

Realising the importance of the process, the Fuel Research Board determined as far back as 1918 to have the matter investigated as thoroughly and as carefully as possible at their fuel research station at East Greenwich, and the report* of their first series of experiments has now been issued. The plant used was designed to carbonise 10 tons of coal per day in four retorts. The amount of steam passed could be varied from 5 per cent. to 30 per cent., and was provided by an independent gas-fired boiler, which made it possible to measure with accuracy both the amount of steam consumed and the heat expended in producing it. The gas used for heating the retort was also carefully measured, and the products resulting from the process were so carefully and exactly weighed that an almost perfect balance was obtained between them and the total weight of the raw materials used. Three different varieties of coal were used in the investigation, and it is proposed to make further tests on other qualities.

The result of the inquiry is to show that not only is there a much larger proportion of the fuel gasified, but there is also an increased yield of tar and ammonia. There is, of course, less coke produced, and it is possible, the report states, that the quality is not so good as when no steam is admitted to the retort. Labour costs are also reduced, owing to the increased output of gas per retort, even should it be necessary to employ a more skilled type of worker. The limit to which steaming can be profitably pushed will, no doubt, vary with different coals, and must be ascertained by direct experiment in each particular case.

With about 20 per cent. of steam and a retort temperature of 1,265 deg. C. as much as 33 per cent. of the total potential heat of Mitchell Main coal was converted into gas of a calorific value of 460 B.Th.U. per cubic foot. Without steam the calorific value was 544 B.Th.U. per cubic foot, but the make per ton was much smaller. In short, the steaming of the retort showed a gain of 33 therms (1 therm = 100,000 B.Th.U.) per ton of coal retorted, whilst the tar was 34 lb. more per ton and the yield of ammonium sulphate was 6 lb. more. To obtain these results the heat expenditure in producing the gas had to be increased by 10 therms. Corresponding, but not quite so favourable, figures were obtained with Consett coal and with Lanarkshire coal.

The composition of the gas is, of course, much altered by the steaming. Thus, without steam the Mitchell Main coal yielded a gas having the following composition: CO_2 0·80; C_nH_m, 2·20; O_2 0·60; CO, 7·40; H_2, 52·00; CH_4, 29·05; N_2, 7·95; whilst when slightly over 20 per cent. of steam was passed into the retort, the gas analysed CO_2, 4·50 C_nH_m, 1·80; O_2, 0·30; CO, 17·80; H_2, 51·60; CH_4, 18·00; N_2, 5·80. The increase in the carbon monoxide makes the gas more poisonous, but the figure of 17·80 per cent. is much below what is common in the United States, where in some cities CO forms as much as one-third of the total bulk.

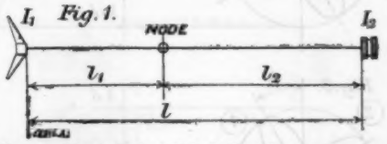
* Report of the Fuel Research Board for the years 1920–1921. First Section: "Steaming in Vertical Retorts." His Majesty's Stationery Office. Price 1s. 6d. net.

ANGULAR VIBRATIONS IN MARINE PROPELLING MACHINERY.

By RICHARD GARDNER.

The existence of torsional vibration of the propeller shafting in ships driven by reciprocating engines is well known; where such vibrations have occurred under conditions of synchronism, what in acoustics is called resonance, the effects have sometimes been disastrous. This vibration effect in relation to geared steam turbine installations has been very little investigated; but it is believed at the present time to be a cause, in many cases, of troubles which have not been satisfactorily explained otherwise.

Fig. 1.



A mechanical vibrating system consists of flexible parts and inert parts, and during vibration, the motion of all the elements is such that some point or node is maintained in equilibrium under the forces about it. (There may be several nodes.) If the flexibility of the system is confined to the torsional flexibility of the shafting between the propeller and the gear wheel, then the latter cannot be a node or equilibrium point, but must, in some degree, be subject to vibration.

The angular vibration of the gear wheel may be so small in amplitude that the only result is a variation of pressure on the teeth, and there is no reason to suppose that this would damage the teeth or even detract from smooth running. A greater amplitude would cause the teeth to come out of contact, and the condition of the teeth in some cases after the gear has run for a short time gives a strong impression that separation and striking of the teeth has actually occurred.

It is notable that the unsatisfactory features found in experience with double reduction gearing were practically unknown so long as gearing was confined to the single reduction type. In order to show a comparison of the two types in relation to the effect of torsional vibrations, let the condition be written down, that separation cannot occur between the gear wheel teeth and the teeth of the corresponding pinion, taking a given angular amplitude, θ_2, of vibration of the gear wheel.

n = frequency of gear wheel vibration.
R = gear wheel radius.
r = pinion radius.
T = torque at pinion.
I = inertia (moment) of turbine rotor,

The vibratory motion of the gear wheel may be expressed thus as a function of the time t:—

Angular displacement $\theta = \theta_2 \cos 2\pi n t$.

Differentiating twice, we have:

Angular acceleration $\ddot{\theta} = -(2\pi n)^2 \theta$

Whence the maximum value of the linear acceleration of the gear wheel teeth is

$$(2\pi n)^2 R \theta_2$$

Taking a single reduction gear first, if the load on the pinion teeth were removed for a short interval as a result of the vibration of the gear wheel then the power would be absorbed by the inertia of the rotor, which would thus accelerate, and the linear acceleration of the pinion teeth would be:

$$r \times \frac{T}{I}$$

The required condition, namely, that the gear wheel teeth cannot get away from the pinion teeth, is that this acceleration shall be greater than the maximum acceleration of the gear wheel teeth, or:

$$\frac{r}{R} \times \frac{T}{I} > (2\pi n)^2 \theta_2$$

To take now the case of double reduction gear, let R_1, r_1 be the radii of the first and R_2, r_2 the radii of the second reduction gears, and let J be the inertia of the intermediate gear element. If a is the acceleration of the intermediate gear when it is free to accelerate along with the turbine rotor, then the corresponding acceleration of the rotor is

$$\frac{R_1}{r_1} a.$$

Therefore

$$I \times \frac{R_1}{r_1} . a + J a = T$$

or

$$a = \frac{T}{\frac{R_1}{r_1} . I + J}$$

and we have as the condition that the gear wheel teeth cannot come out of contact—

$$\frac{r_2}{R_2} \times \frac{T}{\frac{R_1}{r_1} . I + J} > (2\pi n)^2 \theta_2$$

Relative to a single reduction gear, the double reduction gear is thus, on this basis, unfavourably conditioned. Its defect is, principally, the low potential acceleration of the second reduction pinion teeth. It is probable, again, that the conditions determining the factors n and θ_2 are favourable to the single reduction gear.

It appears impossible to treat mathematically the motions of the different elements of a geared turbine installation when the propeller shafting undergoes torsional vibration, but it is quite possible to obtain comparative estimates of the outside limits to the amplitude of vibration in the gearing. The method proposed rests on the assumption that vibrations arriving at the gearing are absorbed solely by the main gear wheel which is keyed on the propeller shafting. The inertia of the other parts of the machinery being thus neglected, the estimated gear wheel amplitude will certainly be too great, but by treating different designs on the same basis a useful comparison can be made.

With the assumption stated, we have the simple vibrating system, of which Fig. 1 is a diagram, consisting of the shafting with the propeller on one end and the gear wheel on the other. Let

n = natural frequency of vibration (per sec.)
d = diam. of shafting, inches.
l = length of shafting, inches.
N = modulus of rigidity, lbs./sq. inch.
I_1 = inertia of propeller, lb.–ins.^{2}.
I_2 = inertia of gear wheel, lb.–ins.^{2}.
g = gravity acceleration, ins./sec.^{2}.

The node divides the length of the shafting into two segments l_1, l_2, which always twist in opposite angular directions, and we have then:—

$$2\pi n = \sqrt{\frac{N}{I_1} \times \frac{\pi d^4}{32} \times \frac{g}{I_1}} = \sqrt{\frac{N}{I_2} \times \frac{\pi d^4}{32} \times \frac{g}{I_2}}$$

Evidently

$$I_1 l_1 = I_2 l_2$$

(We have neglected the inertia of the shafting, for which it is not worth while making any correction.) Let

θ_1 = angular amplitude of propeller
θ_2 = angular amplitude of gear wheel.

For equilibrium at the node, the torsional strain

must be the same in both segments of the shafting:

$$\frac{\theta_2}{l_2} = \frac{\theta_1}{l_1}$$

Therefore:

$$\theta_2 = \frac{I_1}{I_2} \times \theta_1$$

This brings us to the question of the propeller's vibration, of which θ_1 is the amplitude. Suppose the propeller is subjected to a single isolated shock, as by a sudden change in the resisting torque to a higher or a lower value, then the propeller responds with its natural frequency n, the vibrations being gradually damped away by friction; probably such vibrations are always small in amplitude. But when the disturbing force on the propeller is periodic, as is actually the case for all ships, the resulting amplitude of the propeller may be very great. Let the variation in the resisting torque T (in.-lb.) be represented by a harmonically-varying disturbance of amplitude Y, frequency m. Thus T is the average value and $Y \cos 2\pi m t$ is the disturbance of the torque $T + Y \cos 2\pi m t$. This periodic force is applied to the propeller, which has a natural frequency n. The solution of the equation of motion brings out very clearly the nature of the resulting vibration.* It may be written:

$$\theta = T \times \frac{g}{I_1} \times \frac{\cos 2\pi m t}{(2\pi n)^2 - (2\pi m)^2}$$

The frequency is the same as that of the force, and the amplitude is:

$$\theta_1 = T \times \frac{g}{I_1} \times \frac{1}{(2\pi n)^2 - (2\pi m)^2}$$

$$= \frac{T}{I_1} \times \frac{9{\cdot}8}{n^2 - m^2}$$

We have neglected friction, of which the effect increases with the amplitude. If m and n are nearly equal, friction may prevent the amplitude getting so great as to cause destruction of the shafting.

With a four-bladed propeller

$$m = 4 \times \frac{\text{R. P. M.}}{60}$$

assuming that there is one radius in the wake stream where the thrust is a maximum and another where the thrust is a minimum.

From the expressions already given for n in terms of I_1, l_1 or I_2, l_2, we easily find:

$$n = \frac{1}{2\pi}\sqrt{\frac{N}{l} \times \frac{\pi d^4}{32} \times g\left(\frac{1}{I_1} + \frac{1}{I_2}\right)}$$

$$= 3{,}400 \times \frac{d^2}{\sqrt{l}} \times \sqrt{\frac{1}{I_1} + \frac{1}{I_2}}, \text{ taking N}$$

$$= 12 \times 10^6 \text{ lbs./sq. in.}$$

We have, finally,

$$\theta_2 = \frac{I_1}{I_2} \times \theta_1 = \frac{T}{I_2} \times \frac{9{\cdot}8}{n^2 - m^2}$$

This result indicates the benefit of a large and heavy gear wheel. We are not concerned with the sign of $n^2 - m^2$ which only determines the phase of the vibration relative to the phase of the torque variation. In most ships with propelling machinery of the type in question, m is greater than n. It will be seen that with this condition increase of propeller inertia exercises a small effect in reducing the overrunning tendency at the gearing; on the other hand, when m is less than n, an increase of propeller inertia has the opposite effect.

A simple relation may be written connecting torque variation and wake variation. Average torque:

$$T = \text{constant} \times \frac{\text{S. H. P.}}{\text{R. P. M.}}$$

For any given propeller,

$$\frac{\text{S. H. P.}}{(\text{R. P. M.})^3} = \text{constant, approximately.}$$

Therefore:

$$T = \text{constant} \times (\text{R. P. M.})^2.$$

Again, for a given pitch, slip ratio, and speed of ship:

$$\text{R. P. M.} = \text{constant} \times \lambda$$

where

$$\lambda = \text{average value of wake factor} = \frac{\text{speed of ship relative to wake}}{\text{speed of ship relative to still water.}}$$

hence

$$T = K \lambda^2$$

where K is a constant.

* Rayleigh's Theory of Sound, vol. i.

Now the torque variation of amplitude τ is consequent on a wake variation of amplitude μ, say. So we can write

$$T + \tau \cos 2\pi m t = K(\lambda + \mu \cos 2\pi m t)^2$$
$$= K(\lambda^2 + 2\lambda\mu \cos 2\pi m t) \text{ approximately}$$

whence:

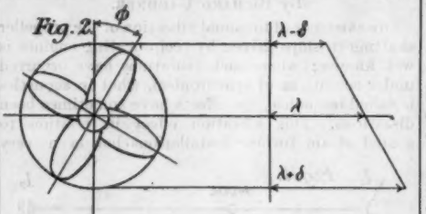
$$\tau = K \times 2\lambda\mu$$
$$= \frac{2\mu T}{\lambda}$$

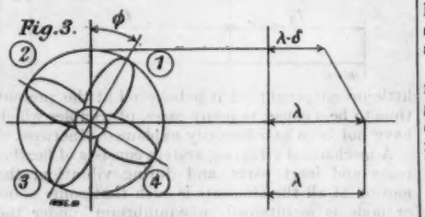
μ is the amplitude of wake variation affecting the propeller as a whole. It must be much less than the amplitude of wake variation experienced by any one blade, because when one blade is in the region of minimum wake another blade will be in the region of maximum wake; in fact, if the wake be supposed to vary according to a simple mathematical law, there may be no wake variation experienced by the propeller as a whole. Regarding the way the wake actually varies over the section of the propeller stream few experimental data are available, but it is not obvious in any case how μ could be found from such data.

Let us start with the simple assumption that the wake factor varies uniformly from $\lambda - \delta$ at the top of the propeller to $\lambda + \delta$ near the keel. The sum of the wake variations for four blades is (see Fig. 2):

$$\delta \cos\phi + \delta \cos\left(\phi + \frac{\pi}{2}\right) + \delta \cos(\phi + \pi) + \delta \cos\left(\phi + \frac{3\pi}{2}\right) = 0.$$

Let the wake factor be supposed constant over the bottom half of the propeller disc, and to vary





uniformly from the centre to the top (Fig. 3), then the wake factor for each blade is as follows:

Blade.	Wake Factor.
(1)	$\lambda - \delta \cos\phi$
(2)	$\lambda - \delta \cos\left(\phi - \frac{\pi}{2}\right)$
(3)	λ
(4)	λ

Hence, wake factor for the whole propeller =

$$\lambda - \frac{\delta}{4}\left[\cos\phi + \cos\left(\phi - \frac{\pi}{2}\right)\right]$$

$$= \lambda - \frac{\delta}{4}\left[\cos\phi + \sin\phi\right]$$

We are considering one-quarter revolution. The greatest value is $\lambda - \frac{\delta}{4}$ and the minimum is $\lambda - \frac{1{\cdot}4\,\delta}{4}$. Hence, let the expression be replaced by the harmonic function:

$$\lambda - \frac{1{\cdot}2\,\delta}{4} + \frac{0{\cdot}2\,\delta}{4} \cos 2\pi m t$$

Thus,

$$\mu = \frac{0{\cdot}2\,\delta}{4} = 0{\cdot}05\,\delta.$$

Suppose $\delta = 0{\cdot}4$, then $\mu = 0{\cdot}02$.

The foregoing is no doubt rough mathematics, but serves to show that a large variation in the wake stream has but a small effect in relation to torque variation. In an interesting paper by Messrs. Walker and Cook, read before the Institution of Naval Architects this year, observations are recorded of the actual fluctuations of twist of a propeller shaft. The ship in question was an oil tank steamer, the San Fernando, in which trouble had been encountered as a result of torsional oscillations. It was found that the shafting vibrated with a natural frequency which corresponded to a nodal position at the gearing. This frequency was about 280 per minute. The revolutions, originally 65 to 70, were reduced to 61·3 by increasing the pitch of the propeller. The twist fluctuation was then observed by moving the torsionmeter scale box to different angular positions round the shaft, and was found to have an amplitude equal to about 33 per cent. of the mean twist. The length of shafting was 35 ft., and shaft horse-power about 5,000. In the absence of more particulars, we will take:

$$d = \sqrt[3]{\frac{70 \times 5000}{65}} = 17{\cdot}5, \text{ say 18 ins.}$$

to allow for stiffness of tail shaft, &c.

$$l = 35 \times 12 = 420 \text{ ins.}$$

$$n = 280 \div 60 = 4{\cdot}67.$$

$$I_1 = \left[\frac{3400}{n}\right]^2 \times \frac{d^4}{l} = 132 \times 10^6 \text{ lb.-ins.}^2$$

corresponding to a propeller about 22 ft. diameter and 45,000 lb. weight.

$$T = 63{,}000 \times \frac{5{,}000}{61{\cdot}3} = 5{\cdot}14 \times 10^6 \text{ in.-lbs.}$$

$$\text{Twist} = \frac{5{\cdot}14 \times 10^6}{12 \times 10^6} \times \frac{420 \times 32}{18^4 \times \pi} = 0{\cdot}0174$$

$$\theta_1 = 0{\cdot}33 \times 0{\cdot}0174 = 0{\cdot}00574$$

$$m = 4 \times 61{\cdot}3 \div 60 = 4{\cdot}09$$

$$\tau = I_1 \theta_1 \times (n^2 - m^2) \div 9{\cdot}8 = 0{\cdot}4 \times 10^6 \text{ in.-lbs.}$$

which is about 8 per cent. of the average torque.

$$\mu = \frac{1}{2} \times \lambda \times \frac{\tau}{T} = 0{\cdot}027 \text{ with } \lambda = 0{\cdot}7$$

This is a full-lined ship, and the value of μ will be high. The provisional figure, 0·02, already arrived at, is therefore probably quite a close approximation for fine-lined or twin-screw ships.

The system of comparison here indicated has, in a number of cases, shown very consistent results. Linear amplitude of gear wheel teeth = $R \times \theta_2$, where R is main gear wheel radius. A gear with a low value of $R \times \theta_2$ is found to be silent and to run satisfactorily; a high value of $R \times \theta_2$ indicates a noisy and troublesome gear.

Let a case be proposed where s.h.p. = 2,500, r.p.m. = 80. Propeller diameter about 17 ft., giving $I_1 = 40 \times 10^6$ lb.-in.^{2}. Shafting diameter d = say, 12¾ in., length $l = 110$ ft. $\times 12 = 1{,}320$ in. Gear wheel radius R = 40 in., $I_2 = 18 \times 10^6$ lb.-in.^{2}:

$$m = 4 \times 80 \div 60 = 5{\cdot}33$$

$$n = 3{,}400 \times \frac{12{\cdot}75^2}{\sqrt{1320}} \times \sqrt{\frac{1}{40 \times 10^6} + \frac{1}{18 \times 10^6}} = 5{\cdot}3$$

$$T = 63{,}000 \times \frac{2{,}500}{80} = 1{\cdot}97 \times 10^6 \text{ in.-lbs.}$$

Take $\lambda = 0{\cdot}7$, $\mu = 0{\cdot}028$, then

$$2\frac{\mu}{\lambda} = 0{\cdot}08$$

Hence

$$\tau = 0{\cdot}08\,T = 0{\cdot}157 \times 10^6$$

$$\theta_2 = \frac{0{\cdot}157 \times 10^6}{18 \times 10^6} \times \frac{9{\cdot}8}{5{\cdot}33^2 - 4{\cdot}3^2} = 0{\cdot}0086$$

and $R \times \theta_2 = 0{\cdot}34$ in., which is too high a figure. Let the design be modified to reduce the value of $R \times \theta_2$. Increase the gear wheel radius to 50 in., thus making I_2 = about 46×10^6 lb.-in.^{2}, and reducing n to 3·29. Then:

$$\theta_2 = \frac{0{\cdot}157 \times 10^6}{46 \times 10^6} \times \frac{9{\cdot}8}{5{\cdot}33^2 - 3{\cdot}29^2} = 0{\cdot}0019$$

$$R \times \theta_2 = 0{\cdot}095 \text{ in.}$$

and the gearing, thus modified, would be expected, from experience with this theory, to be free from effects of the angular oscillations of the propeller.

RECENT MACHINE TOOL DEVELOPMENTS.—No. XXI.

By JOSEPH HORNER.

AN example of a recent motor-driven heavy lathe is the subject of this article. Its general features are apparent from the photograph, Fig. 410, and the front elevation, and plan, Figs. 411 and 412. It is of 20 in. centres, admits a length of 12 ft., and weighs 18 tons, which necessitates a bedding

MOTOR-DRIVEN HEAVY LATHE: 20-IN. CENTRES.

CONSTRUCTED BY MESSRS. FRANCIS BERRY AND SONS, ENGINEERS, SOWERBY BRIDGE.

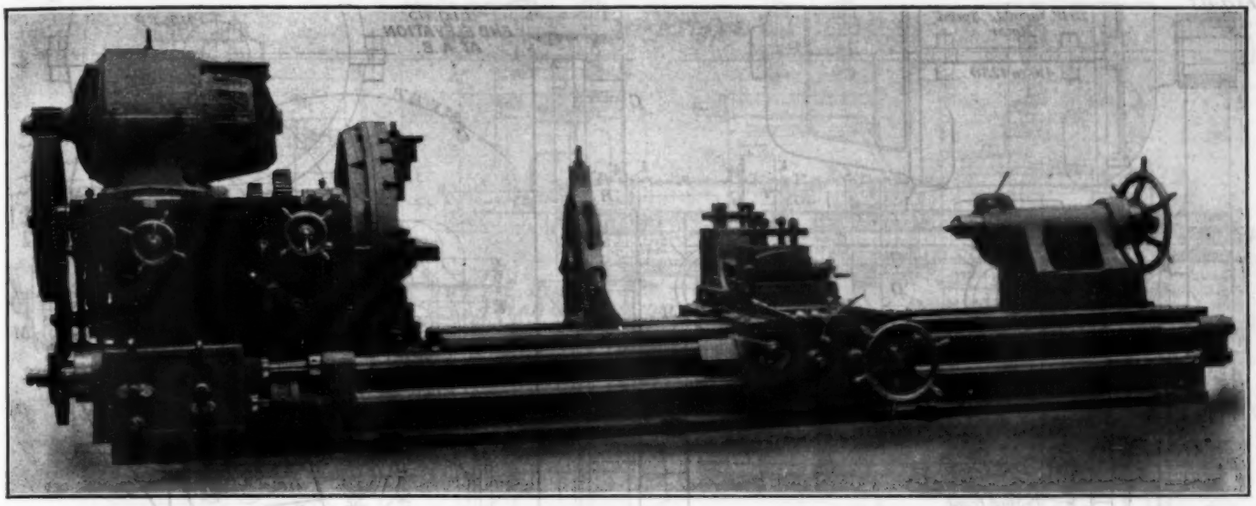


FIG. 410.

Fig. 411.

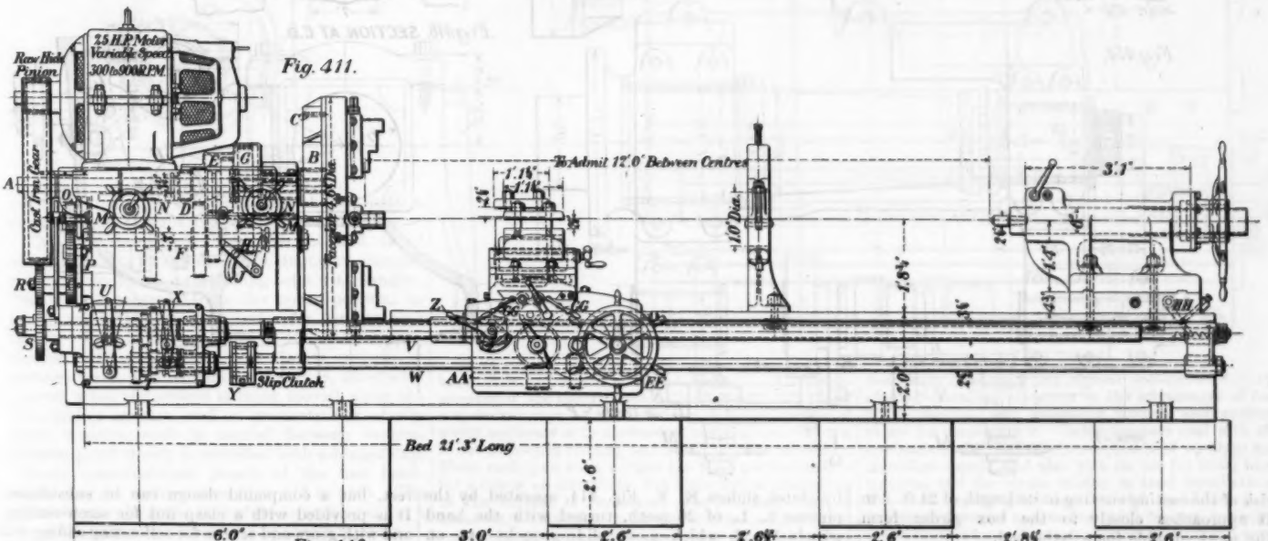
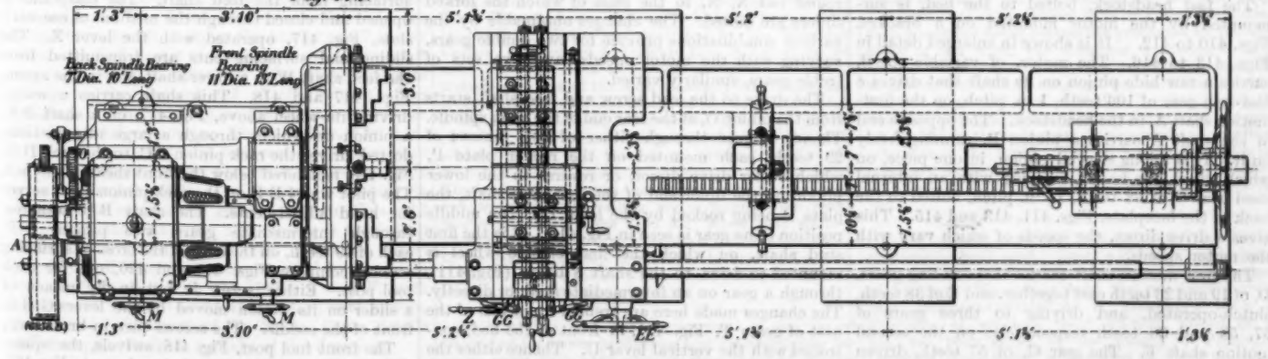


Fig. 412.

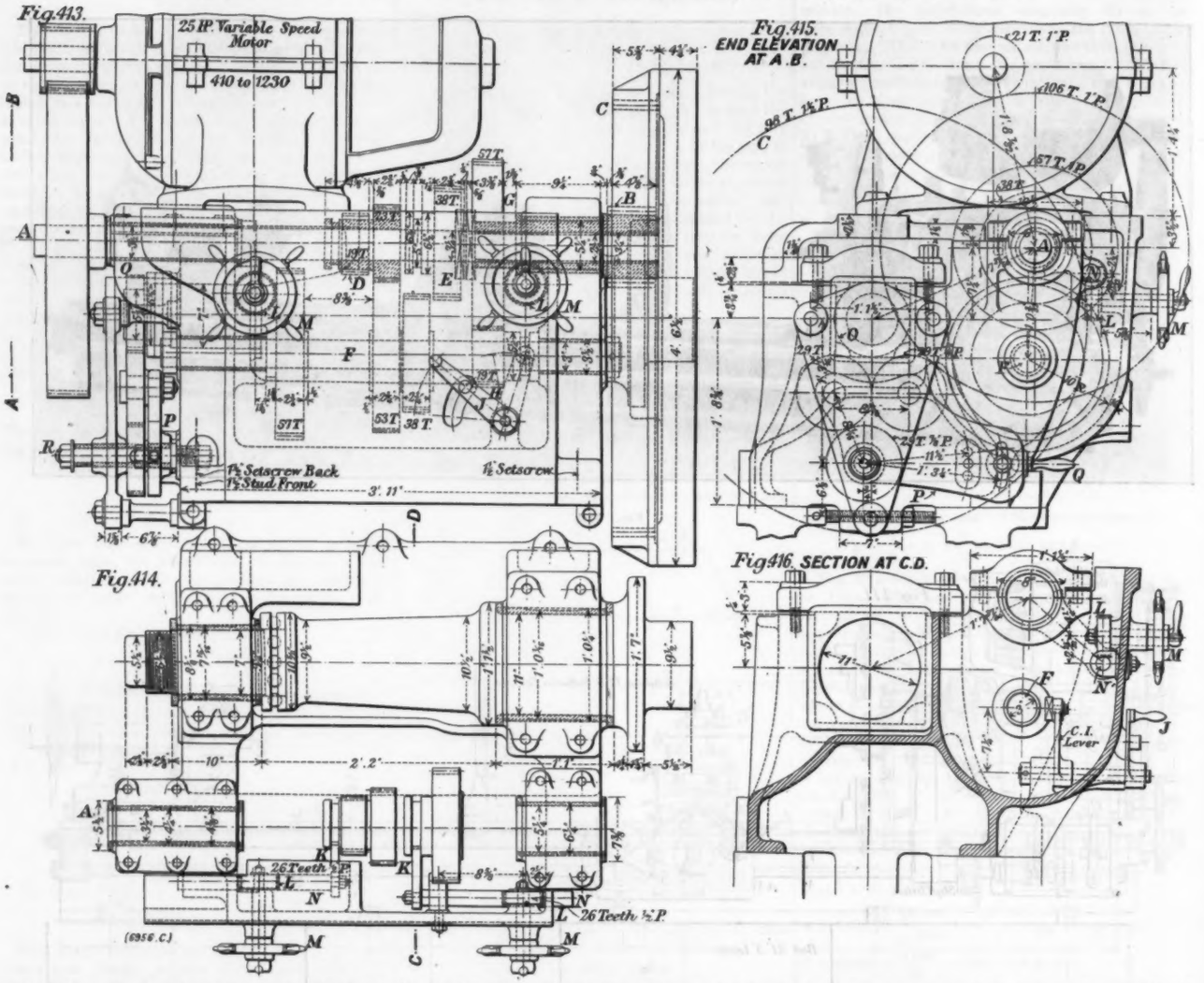


on the four concrete foundations, dimensioned in both views, to which it is secured with 1¼ in. bolts. The makers are Messrs. Francis Berry and Sons, of Sowerby Bridge.

The bed, shown in enlarged cross-section in Fig. 418, page 367, is of great width and depth. It is cast with a wide and deep trough along the rear, into which the cuttings fall through three diagonal holes between the shears, in the localities seen in the plan, Fig. 412. Except for these holes, the bed is plated over solidly. Like so many machine beds now, the narrow guide is confined to the edges of the front shear, a clearance being left between the outer edge of the hinder shear, and the saddle of the slide rest. Adjustment is made, and wear taken up with the long taper gib, against the front edge, having a taper of 1 in 48, Figs. 418 and 420. The great width of bearing surface on the front shear, 10¼ in., where the stress of cutting comes is noticeable. The mass of metal above and below is so nearly equalised that there is practically no

MOTOR-DRIVEN HEAVY LATHE: 20-IN. CENTRES.

CONSTRUCTED BY MESSRS. FRANCIS BERRY AND SONS, ENGINEERS, SOWERBY BRIDGE.



risk of the casting curving in its length of 21 ft. 3 in. It approaches closely to the box girder form, the most suitable for a lathe bed.

The fast headstock, bolted to the bed, is surmounted by the motor mounted on a bracket, Figs. 410 to 412. It is shown in enlarged detail in Figs. 413 to 416. The motor, of variable speed, carries a raw hide pinion on its shaft that drives a cast-iron gear of 106 teeth, 1 in. pitch, on the first-motion shaft A, in the headstock. The opposite end of the shaft A carries a pinion B, running freely on it. It is a long sleeved pinion, in one piece, on which wheel G is keyed, meshing with an internal steel gear C, of 98 teeth, 1¼ in. pitch, bolted to the back of the faceplate, Figs. 411, 413 and 415. This gives a drive direct, the speeds of which vary with the motor speeds.

The first motion shaft carries three sliding gears, D, of 19 and 23 teeth cast together, and E of 38 teeth, clutch-operated, and driving to three gears of 57, 53 and 38 teeth respectively, on the second motion shaft F. The gear G, of 57 teeth, driven when clutched to E, through a sliding pinion H, of 19 teeth, on the second motion shaft F. It is put into mesh by the lever J. Wheel G gives all speeds by means of pinion H except single speed, then pinion H is put out of gear by lever J and clutch wheel E is brought into mesh with clutch on wheel G by means of rack and wheel. The movable gears on shaft A are put in and out by clutch sliders K, K, Fig. 414, operated by the pinions L, L, of 26 teeth, turned with the hand wheels M, M, which move sliding racks cut on round rod N, N, to the ends of which the forked sliders are bolted. The changes obtainable by the various combinations provide for two double gears, varying with the motor speeds, and two sets of treble gears, similarly varied.

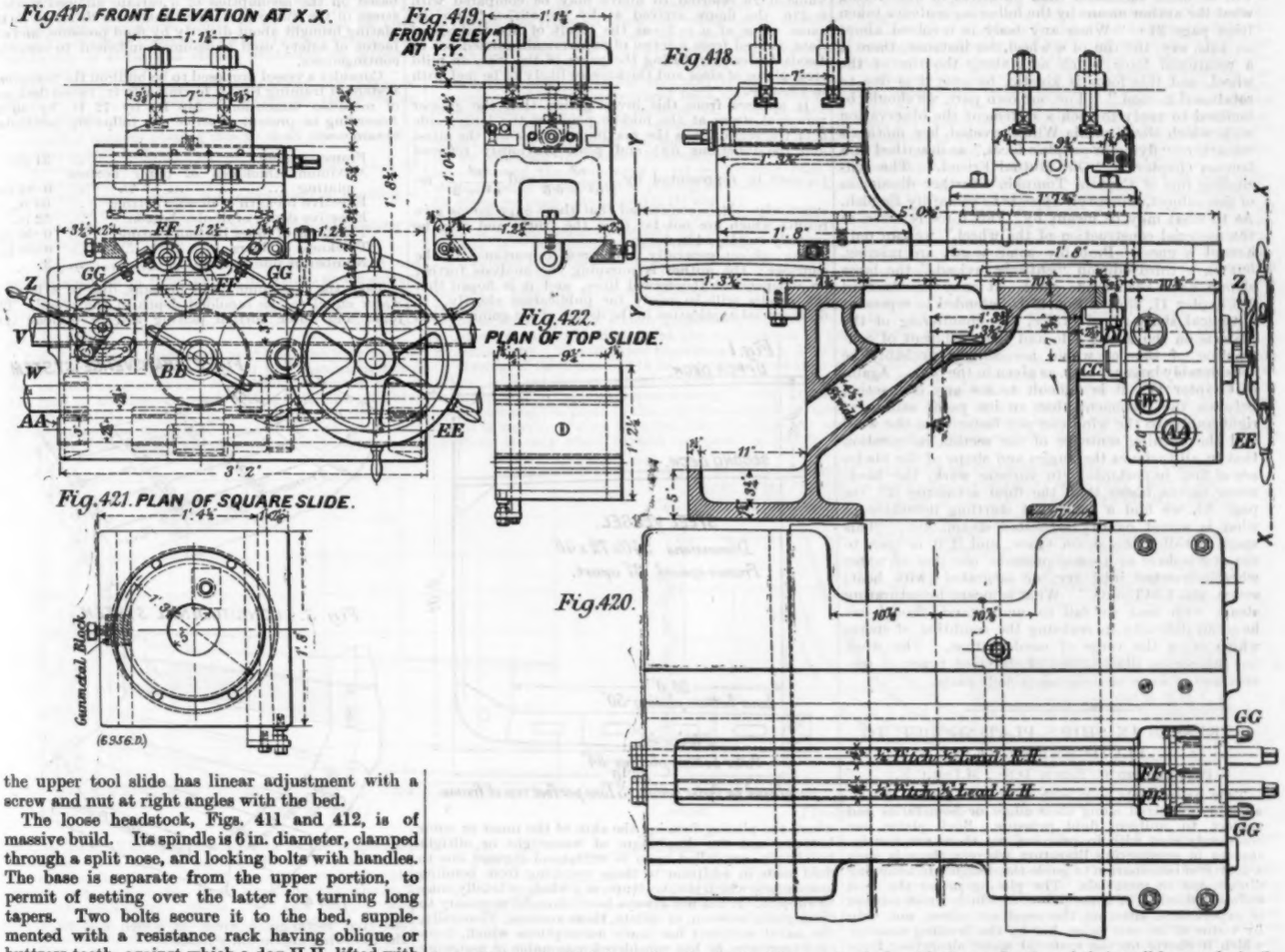
The drive to the lead screw and feed shaft starts from the pinion O, at the rear end of the main spindle. Thence it goes through either of two pinions of 29 teeth, each mounted on the rocker plate P, which either drive direct, or reverse to the lower pinion on the inner end of the first stud shaft, the plate P being rocked by the lever Q. The middle position of no gear is seen in Fig. 415. R is the first stud shaft, on which the first change wheel is mounted to drive to the shaft S below (Fig. 411), through a gear on an intermediate stud, or directly. The changes made here are trebled by means of the nest of gears T, Fig. 411, in front of the bed, controlled with the vertical lever U. Thence either the lead screw V, or the feed rod W, is clutched with the lever X. A slip clutch Y is a safety provision for the gears when exceptionally heavy feeds are in. Rack feed is also provided with a large pilot wheel for rapid adjustments of the carriage along the bed.

The slide rest, Figs. 411, 412, and 417 to 422, has a tool post at front and back. It is a swivel rest, but a compound design can be substituted. It is provided with a clasp nut for screw-cutting, and with gears and screws for self-acting sliding and surfacing from the feed shaft. The clasp nut is opened and closed through the medium of eccentric slots, Fig. 417, operated with the lever Z. The sliding and surfacing cuts are transmitted from the feed shaft W to a lower shaft A A in the apron, Figs. 417 and 418. This shaft carries a worm, driving its wheel above, Fig. 417, on a shaft B B, a pinion on which, through a large intermediate, dotted, drives the rack pinion C C, to the rack D D, Fig. 418, registered below the front shear of the bed. The pilot wheel E E on the rack pinion shaft serves for hand adjustments. The shaft B B actuates, through intermediate gears, two pinions F F, each of 19 teeth, on the ends of the cross or surfacing screws, compare Figs. 417 and 420, one for each tool post. Either screw is put in by means of a slider on its pinion moved by the levers G G in front of the saddle. The screws turn in brass nuts.

The front tool post, Fig. 418, swivels, the square slide with its annular groove being shown in Fig. 421. It fits the carriage with the vee'd edges, and has a taper gib adjusted with a screw for taking up wear. On this is mounted the main casting, cored, which receives the top slide, of steel, fitted similarly to the lower slide, with taper gib (Fig. 422), and carrying four clamping bolts with their plates for tools. The hinder tool post fits directly to the saddle, and

MOTOR-DRIVEN HEAVY LATHE: 20-IN. CENTRES.

CONSTRUCTED BY MESSRS. FRANCIS BERRY AND SONS, ENGINEERS, SOWERBY BRIDGE.



the upper tool slide has linear adjustment with a screw and nut at right angles with the bed.

The loose headstock, Figs. 411 and 412, is of massive build. Its spindle is 6 in. diameter, clamped through a split nose, and locking bolts with handles. The base is separate from the upper portion, to permit of setting over the latter for turning long tapers. Two bolts secure it to the bed, supplemented with a resistance rack having oblique or buttress teeth, against which a dog H H, lifted with a screw when the poppet is being moved along the bed, makes contact, and so prevents risk of slip when massive work is carried between centres. A three-point steady is provided with a hinged cap.

Some constructional details of the fast headstock may be noticed (see Figs. 413 to 416). The spindle into which the face-plate is registered on a flanged extension is a steel forging, shown in Fig. 414. It runs in parallel gun-metal bearings, of ample proportions. The front bearing measures 11 in. in the bore, by 13 in. long, the hinder one 7 in. by 10 in. A ball thrust is fitted in front of the hind bearing. Wear is taken up with three locknuts fitting on the screwed tail of the spindle. The bearings for the shafts A and F, of gun-metal, are also large and very long. The faceplate, 4 ft. 6 in. in diameter, is fitted with four cast steel boxes, seen in the photograph, Fig. 410, with reversing chuck jaws of forged steel. The headstock casting is designed to enclose the gears—compare Figs. 410 with Figs. 415 and 416. The casting is carried up high, and stiffened with a fillet round the edges. A mid-rib divides the space occupied by the main spindle from that with the shafts A and F, with their gears, Figs. 414 and 416. Lugs, with screws, provide for alignment of the head. Other details will be apparent from a study of the drawings.

NOTES ON NEW BOOKS.

NOWADAYS the electric motor has so pushed itself into almost every type of power application that every practical working engineer finds it necessary to know something about it. Matters were very different no great number of years ago, when electrical engineering was an isolated business of which the mechanical man knew little and which he rather despised. The omnipresence of the electric motor now compels very many non-electric men to run it, and in a large number of works engineers with mechanical training not only run it but to keep it running and repair it when necessary. Many such men have neither the time nor inclination for a course on electricity, but some sort of reading-up of the subject is necessary. The ordinary sort of elementary text-book is no use to them. They want something more immediate and more practical—something indeed on the lines of "*A Practical Treatise on Three-Phase Induction Motors*," which has been written by Mr. L. E. Wood, and published by The Electrical Review, Limited, of 4, Ludgate Hill, E.C.4, at 6s. 6d. net. This little book is in every way practical, and as it deals with one of the most generally distributed and commercially important pieces of electrical apparatus, it should be of considerable service to a large number of users. The book sticks to its subject in the most admirable way, and there is no attempt to give the reader a general electric training as a side issue. The book naturally has the limitations of its own scope but there is little calling for criticism. We really however, cannot agree with Mr. Wood that while a phosphor-bronze bush may seize on a steel shaft owing to the shaft expanding more than the bush on heating, it will refuse to come off when cooled owing to the bush contracting more than the shaft.

So great has been the development in the use of liquid fuel for power production and heating during the seven years that have elapsed since the first edition of "*Mex Fuel Oil*" was issued, that the second edition is, if anything, overdue. Its publication at the present time is, however, particularly opportune, since one of the effects of the recent coal strike has been to render public interest in the subject of liquid fuels more widespread than was ever before the case. The book we are referring to has been prepared by the Anglo-Mexican Petroleum Company, Limited, and it first deals with the production of their well-known fuel oil, afterwards calling attention to the advantages of fuel oil in general, and describing burners and systems in use for employing it. Later chapters deal with the application of oil fuel to the propulsion of warships and merchant vessels, and also with its use for firing locomotives, and for steam raising in land installations. The last two chapters are devoted to oil firing for industrial furnaces and to heavy oil engines, including Diesel engines for marine and stationary work and semi-Diesel engines of the cold-starting and hot-bulb types. The treatment of the subject is by no means exhaustive, such treatment being necessarily precluded by the wide scope of the work, but attention is carefully drawn to the main features of each application and the numerous illustrations ranging from an oil-fired cooking range to a general view of H.M.S. Hood, will give the reader a very good idea of the position now occupied by oil fuel in the industrial, commercial and maritime activities of the world. The book is published for the company by Messrs. George Philip and Son, Limited, 32, Fleet-street, London, E.C.4., and its price is 10s. 6d. net.

Thirty or forty years ago, the youth with a mechanical or scientific bent, read "Ganot's Physics" with almost the same zest as the works of the popular tale writers of his day. We gather from the publisher's notice that Engineer-Captain A. E. Tompkin's book on *Turbines*, of which a third edition, priced at 8s. net. has been issued by the Society for Promoting Christian Knowledge, is intended to meet the needs of the inquiring youth of to-day, who, if satisfied with the fare thus offered him, must be considerably more intelligent than his predecessors of a couple of generations ago. Speaking as a survivor from the era referred to, and as one who has to some extent specialised on the subject of which Captain Tompkins treats, we must confess that in repeated instances we have quite failed to grasp the author's meaning

whilst in other instances he is unmistakably in error. The distinction between a re-action and an impulse turbine, drawn on page 3, appears to be misleading, to say the least, and we do not know whether our readers will be more successful than ourselves in discovering what the author means by the following sentence taken from page 21: "When any body is revolved about an axis, say, the rim of a wheel, for instance, there is a rotational force which acts along the rim of the wheel, and this force is kinetic, because it is due to rotational motion." For our own part, we should be inclined to apply to such a statement the observation with which Miss Lavinia Wilfer greeted her mother's remark re "flying in people's faces," as described in a famous chapter of "Our Mutual Friend." The concluding line of Captain Tompkin's further discussion of this subject, moreover, appears to be hardly English. As to what may be meant by "this force is taken in the material construction of the wheel," we can only hazard a guess. Probably some words are missing, but in a third edition, "entirely revised," the lapse should have been made good. It may be observed in Chapter II. that if Fig. 15 be intended to represent a typical sharp-edged orifice, the chamfering of the plate is on the wrong side and the coefficient of contraction of the jet would accordingly probably be considerably larger than $\frac{1}{2}$, as given in the text. Again, in Chapter IV., it is difficult to see any connection between the statement that an ice yacht sailing at right angles to the wind can sail faster than the wind and the opening sentence of the section in question that in all turbines the angles and shape of the blades are of first importance. In turbine work, the blade never moves faster than the fluid actuating it. On page 80, we find a somewhat startling definition of what is meant by dry saturated steam, viz., "This space is called the steam space, and if it is open to the atmosphere at normal pressure, one pint of water when converted into dry, or saturated (with heat) steam, fills 1,643 pints." What is meant by saturating steam with heat we fail to understand, though we have no difficulty in realising the condition of steam which is on the verge of condensation. The work has numerous illustrations of different types of turbine and of some of their component parts.

STRESSES IN SHIP'S PLATING DUE TO FLUID PRESSURE.*

By BERNARD C. LAWS, D.Sc., M.Inst.C.E.

THIS paper deals only with mild steel plates of rectangular area fixed along their edges or boundaries and subject to uniform fluid pressure. Such plates are commonly met with in practice, yet there are few instances in engineering literature wherein there is such a dearth of information to guide the designer in assigning dimensions to materials. The plating under the load suffers deflection, in consequence of which direct tension is experienced affecting the resultant stress, not only by virtue of its own value, but by the bending moment which it exerts on the material apart altogether from that resulting from the action of the direct load.

It seems, at present, that the determination of stress is only possible by subjecting the plating to experiment and making a mathematical analysis of the derived data. So far as the author is aware, no conclusive experiments have been carried out on stiffened or reinforced plates, and only a few instances are known where free plate areas have been so treated.

Until comparatively recently, Grashof's expressions afforded the only aid to designers, but it has come to be realised that the results obtained thereby are wide of the truth. If a and b denote the sides of a rectangle and $n = a/b$, these expressions may be written thus:—

$$\text{Maximum stress} = p = \frac{n^4}{2(n^4+1)} \cdot \frac{w.b^2}{T^2} = f(n) \cdot \frac{w.b^2}{T^2}$$

$$\text{Maximum deflection} = \delta = \frac{n^4}{(n^4+1)} \cdot \frac{w.b^4}{32\,E.T^3}$$

$$= \phi(n) \cdot \frac{w.b^4}{32.E.T^3}$$

where w = unit load on, and T = thickness of, the plate.

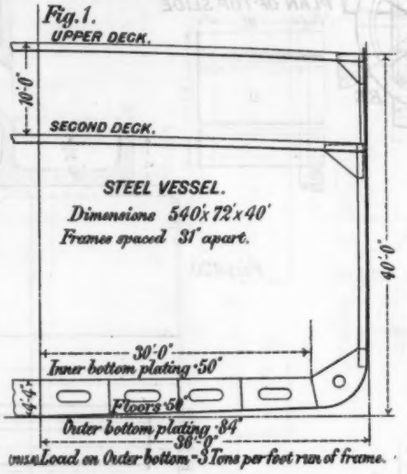
That the expression for p, at least, is unsatisfactory seems to be indicated by the fact that plates recover and experience long life after being repeatedly subject to loads which, according to Grashof, should be sufficient to break them down.

Crawford † experimented on a number of small planished steel plates and concluded that Grashof was about correct for deflections, but for stress was about 35 per cent. low. Steel, surface treated in this way, is likely to give, for the same deflection, stress values much in excess of what would be anticipated with ordinary mild steel direct from the mills, and it may be that his conclusions have no application to the material in general use for constructional purposes.

Later Montgomerie ‡ made some experiments on mild steel plates of a size 48 in. by 24 in., and concluded that the coefficient—$f(n)$—could be taken = 0·26 (by Grashof = 0·47). Bruhn * and Boobnoff † investigated the subject theoretically and endeavoured to find a path by making assumptions which are not altogether convincing, and their conclusions resulted in expressions and tables, respectively, unsuitable for ready use. The value 0·26 referred to above may be compared with 0·276, the figure arrived at by the author ‡—for the same value of $n = 2$—as the result of his analysis of data derived from a series of experiments carried out at Leeds University during the years of the war, on mild steel plates of sizes and thicknesses likely to be met with in practice.

It appears from this investigation that the greater principal stress at the middle point of the longer side a of the rectangle is the maximum stress for the plate, and the functions $f(n)$ and $\phi(n)$, previously referred to, may be represented by $\frac{n^2}{2n^2+6{\cdot}5}$ and $\frac{n^4}{n^4+2}$, respectively. It is considered that these expressions give results which are not far from the truth, and may be usefully employed in design.

The subject generally is of great importance to the engineer; the author is pursuing the analysis further on independent theoretical lines, and it is hoped that the results will be ready for publication shortly. It finds special application in the design of sea-going vessels,



where the plating forming the skin of the inner or outer bottom, and the diaphragm of watertight or oiltight bulkheads, are called upon to withstand stresses due to fluid loads in addition to those resulting from bending moments to which the structure, as a whole or locally, may be subject. It has not always been thought necessary to distinguish between, or collate, these stresses. Generally, the naval architect has made assumptions which, from his experience, he has considered reasonable in assigning scantlings to vessels to be built. Usually scantlings are apportioned in accordance with the prevailing practice of one or other of the "Societies for the Registration of Ships" except in the case of war vessels where the current Admiralty practice obtains, and in certain shipbuilding establishments where a staff is maintained specially for the purpose of investigating such problems.

The rules of classification societies are the result of experience of sea-going vessels ranging over a great number of years. For the most part they have been built up from practical, rather than on theoretical, lines, and have formed, from time to time, the basis upon which various technical committees, brought together to consider—directly or indirectly—questions of structural strength of ships, have formulated their recommendations. The increase in scantlings which has accompanied the development in size of floating structures during recent years has caused the designer, or builder, to turn his attention to the question of economy in materials. It has been thought that the thickness of plating assigned to certain parts of the structure might be reduced—the necessary strength being still maintained—and this idea has received encouragement from the fact that stresses induced in the plating by the action of fluid pressures are generally not so great as had been supposed. The structure of a ship is complex and generally subject to conflicting forces. The plating experiences:—

Stress due to longitudinal bending of the structure as a whole.

Stress due to transverse bending of the structure as a whole.

Stress due to local bending—of beams, frames, &c.

Stress due to fluid pressure.

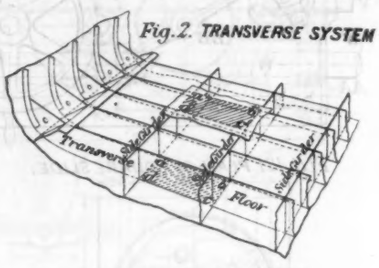
Of these only the first three have been considered generally to be calculable with a desirable degree of approximation.

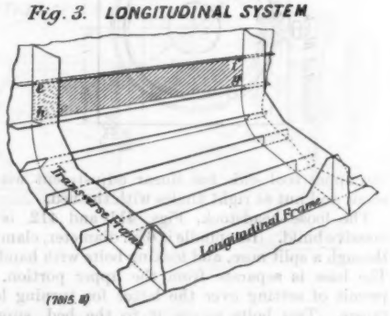
When a design is put forward in which it is proposed to make a departure from the prevailing practice so that the usual rules do not apply, then either certain proportionate allowances are made as the result of experience, or the strength of the proposed structure is independently calculated. The calculations are usually based on the assumption of a certain allowed working stress in the material without reference to stress in the plating brought about directly by fluid pressure, and the factor of safety used is assumed sufficient to cover all contingencies.

Consider a vessel proposed to be built on the transverse system of framing Fig. 1, having a 10 ft. 'tween deck and of moulded dimensions—540 ft. by 72 ft. by 40 ft. According to present practice the following particulars obtain:—

Frame spacing	31 in.
Maximum thickness of outer bottom plating	0·84 in.
Effective breadth of double bottom	60 ft.
Effective depth of double bottom ...	52 in.
Thickness of inner bottom plating ...	0·50 in.
Thickness of floors	0·50 in.
Number of side girders	3.

Take the maximum fluid pressure due to a head of water equal to the moulded depth of the vessel. The inner and outer bottom plating will be divided into





effective rectangular areas in which $n = 3$. We get the following maximum stresses:—

(1) In outer bottom plating a, b, c, d—Fig. 2.

Due to transverse bending	= 1·71 tons per square inch in the transverse direction.
Due to longitudinal bending	= 7·6 tons per square inch in the longitudinal direction.
Due to fluid pressure	= 3·23 tons per square inch in the longitudinal direction. = 1·41 tons per square inch in the transverse direction.

i.e. resultant stress in longitudinal direction = about 11 tons per square inch and resultant stress in transverse direction = about 3 tons per square inch.

(2) In inner bottom plating a' b' c' d'—Fig. 2—(ballast tank filled and head of water to upper deck):—

Due to transverse bending	= 2·34 tons per square inch in transverse direction.
Due to longitudinal bending	= 7·0 tons per square inch in longitudinal direction.
Due to fluid pressure	= 8·0 tons per square inch in longitudinal direction. = 3·5 tons per square inch in transverse direction.

i.e. resultant stress in longitudinal direction = about 15 tons per square inch and resultant stress in transverse direction = about 6 tons per square inch.

The resultant stress in the inner bottom plating generally will not assume so large a value as that indicated, except in those special circumstances in which for some reason, part of the double bottom is filled at the time the vessel is otherwise practically fully loaded. But that the stress might assume a large value, is due to the comparatively large value of the "direct stress resulting from fluid pressure" which might be obtained. Obviously the latter is such that it cannot be disregarded in estimating the strength of the structure. A stress of about 11 tons is probably a maximum value for the

* Paper read before Section G of the British Association at Edinburgh, September 8, 1921.

† Proceedings Royal Society of Edinburgh, Vol. xxxii.

‡ Transactions of the Institution of Naval Architects, vol. lxi.

* Transactions of the Institution of Engineers and Shipbuilders in Scotland, vol. 48.

† Transactions of the Institution of Naval Architects, vol. xliv.

‡ Thesis for Doctorate, London, 1920.

bottom plating and would reduce the factor of safety below what is generally assumed in ship calculations, by about 40 per cent. Seldom has bottom plating been found to fail in practice, and in the exceptional cases the causes may generally be traced to abnormal conditions of weather or loading, or both, producing in the material stresses in excess of the elastic limit. The curved form sometimes found to be assumed by shell plating between the frames seems also to point to abnormal conditions of stress and strain, producing an ultimate set in the material.

In a vessel of more moderate dimensions, viz., 300 ft. × 42 ft. × 25 ft., the following maximum stress values would obtain :—

In outer bottom plating due to fluid pressure = 3·1 tons per square inch.

In inner bottom plating due to fluid pressure = 5·86 tons per square inch.

In outer bottom plating due to longitudinal bending = 6·5 tons per square inch.

In inner bottom plating due to longitudinal bending = 4·6 tons per square inch.

i.e., resultant stress in outer bottom plating = 9·6 tons per square inch in longitudinal direction, and resultant stress in inner bottom plating = 10·46 tons per square inch in longitudinal direction, values which, though much less than those estimated for the larger vessel, are still high.

Had the vessels been constructed on the longitudinal system—Fig. 3—the direction of the maximum stress due to fluid pressure would have been transverse, and in the case of the larger vessel with a thickness of outer bottom plating = 0·80 in., the stress in the longitudinal direction would have been 0·66 tons per square inch, and that in the transverse direction 3·56 tons per square inch. The resultant stresses in the longitudinal direction = 7·5 tons per square inch, and in the transverse direction = 4·56 tons per square inch, values much more reasonable than those quoted above for the transverse framed vessel. For this reason, vessels so built that the panel plating is disposed with the longer axis in the longitudinal direction are generally conducive to a more economic distribution of material. This aspect of the problem was apparently reached by Sir Joseph Isherwood at the inception of the system of longitudinal ship construction bearing his name, and while modifications have since been made in the scantlings of vessels built in accordance with his system, he appears to have seen little reason to vary much from the dimension ratio of the panel plating first proposed.

In the more or less vertical sides of the vessel and in longitudinal bulkheads, stress in the plating due to *shear* will have a distinct influence on the resultant stress—depending upon the position considered, *e.g.*, near the neutral axis—*e f g h*, Fig. 3—the shear stress is considerable and equal to about 4½ tons per square inch, while the stress due to longitudinal bending is zero, the maximum stress due to fluid pressure = 3·6 tons per square inch (transverse) and that due to transverse bending = 1·2 tons per square inch—resulting in a maximum stress of 7·9 tons per square inch. Had the direct stress due to fluid pressure been disregarded the resultant stress would have been 5·14 tons per square inch only.

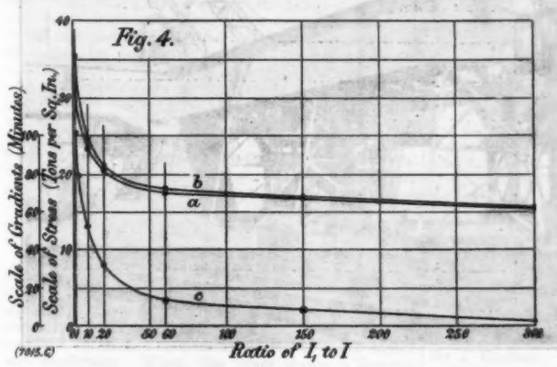
But apart from the effect of fluid pressure upon the stress in the plating, that upon the attachment rivets at the boundaries must also be considered. If the plating is continuous past the boundaries the chief function of the rivets is to hold the plating down, and the shear stress on the rivet is practically negligible. If the plating be not continuous the direct tension in the plating, consequent upon its change of form under the load, produces shear in the rivets which might reach a considerable value. The number and size of rivets required will, in part, depend upon the dimension ratio, as distinct from the superficial area of the plate.

For example, consider a watertight bulkhead in which the plating is 0·40 in. thick, with stiffeners spaced 30 in. apart, subject to a maximum head of water of 36 ft. The stress in the plating due to direct tension may be taken as 1·4 tons per square inch. If the plating be fitted vertically and the stiffener be attached at the landings, then, with ¾-in. rivets spaced 4½ diameters apart, the shear stress in the rivets = 4·07 tons per square inch. The pull along the axis of the rivet may reach 0·68 tons per square inch producing, when combined with the above value for shear, a resultant stress of 4·42 tons per square inch—a value sufficiently high to give warning that if the riveting in the landings is to be utilised for the purpose of attaching stiffeners to the plating the rivets should either be increased in diameter or spaced closer, or both.

In the above consideration the stiffeners are presupposed to form perfect boundaries to the intervening plate areas ; but, in practice, such boundaries generally are not perfect, the stiffeners forming them deflect, and so relieve the rivets of shear—to what extent must be decided by the designer from his experience.

But apart from the foregoing special case, instances arise in practice wherein—if it is desired not to exceed a certain thickness—the plate area may become too large to support of itself the required load, and stiffening or reinforcement has to be resorted to. The necessary strength may generally be produced in one of three ways : (*a*) By increasing the thickness of the plating ; (*b*) by doubling the plate—if already fitted—over the area between the boundaries ; (*c*) by riveting bars of angle or other section to the plating at chosen intervals. Of these we need only consider (*b*) and (*c*).

An impression of the effect of (*b*) may be obtained from a recent communication* by the author on the subject of "Reinforced Thin-Plate Beams," in which the problem is discussed mathematically. In the paper referred to, the variation of "Maximum stress in the plating" with the ratio of "Moment of inertia of the reinforced plate to moment of inertia of free (original) plate section—I_1/I—is shown graphically together with a curve of variation of slope at the termination of the reinforcement. The diagram reproduced in Fig. 4 refers to plating of thickness 0·176 in., of clear (free) span = 22 in., and subject to a load = 0·007 tons per square inch, the span of the reinforcement being 17·6 in. Clearly by reinforcing the plate in this way the stress is reduced, but it is worthy of note that the reduction in stress and gradient is very small beyond the point at which the value of I_1/I is about 50 to 60, *i.e.*, the advantage accruing from adding a doubling plate would reach a maximum for a thickness of the doubling equal to 2½ to 3 times that of the original plate, but for thicknesses much less than this the proposition would be uneconomical.



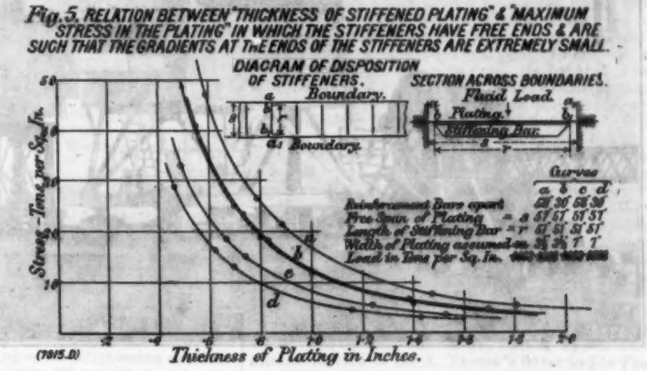


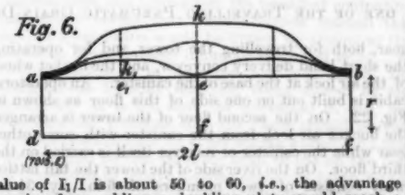
Fig. 5. RELATION BETWEEN "THICKNESS OF STIFFENED PLATING" & "MAXIMUM STRESS IN THE PLATING" IN WHICH THE STIFFENERS HAVE FREE ENDS & ARE SUCH THAT THE GRADIENTS AT THE ENDS OF THE STIFFENERS ARE EXTREMELY SMALL.
DIAGRAM OF DISPOSITION OF STIFFENERS.
SECTION ACROSS BOUNDARIES.
Fluid Load.
Plating.
Stiffening Bar.
Boundary.
Curves
Reinforcement Bars apart
Free Span of Plating = s
Length of Stiffening Bar = r
Width of Plating assumed as
Load in Tons per Sq. In.
Stress - Tons per Sq. In.
Thickness of Plating in Inches.
(7915.D)

The resultant stress in the plate $a\ b$ will be something intermediate between those represented by the ordinates of the curves $a\ k\ b$, $a\ k'\ e$ and is indicated by the chain-dotted line curve in the same diagram.

A further consideration of the subject is illustrated in Fig. 5, in which an elongated area of plating fixed all round its edges is reinforced with free-ended stiffeners. The diagram indicates the relation between "maximum stress" to "thickness" under conditions of different widths m of plating, the bar being assumed so stiff that the gradient of the plate at the ends of the bar is negligible.

The broken line curve in this diagram represents the maximum stress in the unstiffened plating under a unit load equal to the unit of fluid pressure, viz., $w = 0{\cdot}008$ tons per square inch, and practically coincides with that representing the maximum stress in the plating with stiffeners spaced 30 in. apart, and in which $m = 3\frac{1}{2}$ in., and the load $w = 0{\cdot}0508$ tons per square inch.

In practice, we should not expect to fit stiffeners much closer than 30 in. apart, and for plating say of thickness 0·76 in., the stress would be 22 tons per square inch when $m = 3\frac{1}{2}$ in., and 11 tons per square inch when $m = 7$ in.—stress values which would correspond with the thickness 0·84 in. in the bottom plating of the 540 ft. vessel referred to previously if the floors were placed on alternate frames, i.e., 62 in. apart, and two side girders omitted. To bring the stress to a reasonable value, either the thickness of the plating would require to be increased or the stiffeners placed so close as to bring a solution on these lines outside practical economics in actual ship construction. In this respect, the diagram has special application to the tendency during recent years to space floors wider and fit fewer side girders than is usual in the standard practice of transverse framing, and indicates how, in such cases, the maximum spacing of floors, and the minimum spacing of stiffeners, may jointly be reached when looked at from the point of view of stress and economy in material.



On theoretical grounds, it would seem that at those parts of a vessel where the plating is subject to a considerable fluid pressure, free-ended stiffening bars should not be used, and this conclusion finds confirmation in the results of some tests on actual bulkheads, carried out by the Bulkhead Committee some years ago, in which the plating was reinforced in the usual manner by stiff bulb angles either bracketed or free at the ends.

Where under fluid pressure—which could not be considered excessive—the bulkheads with bracketed stiffeners satisfactorily withstood the tests put upon them, yet when the brackets were removed and the stiffener itself reinforced by riveting thereto a substantial face bar, the plating at the ends of the bar bulged very perceptibly, and the lower end of the stiffeners cut into the plating under loads which might be considered as normal, and less than that imposed on the bulkhead in the previous test referred to above.

The required ratio of I_1/I may be obtained economically by reinforcing the plating at intervals with bars of suitable section—(*c*). The stiffener—and with it a portion of the plate—by virtue of it partaking wholly or partially of a rigid boundary, will attract to itself a unit load > the unit fluid pressure, and, in consequence, the stress in the plating will undergo a change which may or may not be satisfactory.

In Fig. 6 let the ordinates of the curve $a\ k\ b$ denote the greater principal stress at any point along the side $a\ b$ of the rectangle $a\ b\ c\ d$ of which the edges form rigid boundaries. If a similar boundary be interposed at $e\ f$, the curve $a\ k\ b$ is changed to $a\ k'\ e$, and the load taken by $e\ f$ may be approximately represented by $\frac{r^2 w}{2}$ or $l\,w\left(r - \frac{l}{2}\right)$ according as $l >$ or $< r$. If $e\ f$ be only partially rigid, so that it experiences deflection, the value of the load will be something between $w\ r$ and that represented by the above expressions. But suppose $e\ f$ having free ends, is of length a little $< r$ and otherwise perfectly stiff, then it may reasonably be assumed that the load which it carries will not differ much from that expressed above for a rigid boundary.

Further, it is problematical to what extent on either side of $e\ f$ the plating is directly affected by the stiffener. In practice the length of the latter would be $< r$ by only some 3 in. or 4 in., and at e and f the width of plating affected would probably not exceed the same amount where the stiffener is attached by a single row of rivets. The exact amount of plating is theoretically indeterminate and a virtual width m can only be determined by experiment. The stress, however, at any point of the plating may be reached when looked at from the point of view of stress and economy in material.

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THE INDUCTION FURNACE.—Induction electric steel furnaces, reports *The Iron Age*, of New York, have played only a small role in the recent expansion of the American electric steel industry. Only one furnace of this type may be said to have operated successfully for any considerable time, and this is the furnace developed by the General Electric Company. There were over 350 arc furnaces in American plants at the opening of this year. It appears that in the General Electric Company's furnace two radical changes have been adopted, which overcome the obstacles to previous attempts with this type in the United States. The placing of the entire primary coil on top is one departure, and a vital one, because any breaking through of hot metal cannot harm an expensive part of the equipment. The development of a special refractory is another step in advance. Much depends on the lasting qualities of the lining of induction furnaces, and it was the fact that Austrian magnesite could not be obtained during the war which in large measure prevented the use of two or three induction furnaces in American steelworks. Germany has been, and still is, the country in which induction furnaces have a prominent place in steel making. This is explained partly by the fact that in the early days an arc furnace was as expensive to instal as an induction furnace. It is probable that in the United States the induction type can never compete seriously for general purposes, in view of its first cost, with the arc furnace, but its field will be in the making of unusual and specially high-grade steels, or, possibly, in special duplexing operations.

* Phil. Mag., vol. 42, August, 1921.

PNEUMATIC GRAIN-DISCHARGING PLANT AT BORDEAUX.

FIG. 20. VIEW SHOWING ONE OF THE TRAVELLING PNEUMATIC GRAIN-DISCHARGING TOWERS.

PNEUMATIC GRAIN DISCHARGING AND SACK HANDLING PLANT AT BORDEAUX.

(*Concluded from page* 314.)

IN our previous article we dealt with the fixed part of this plant, the gantries, silo arrangements, &c., with the belt conveying and elevating machinery and with the vacuum pumps or exhausters for which Messrs. Thomas Robinson and Son, Limited, Rochdale, were the contractors, this firm being responsible for the design, and the whole plant being erected under their supervision. We now propose to deal with the travelling towers of the pneumatic plant. The structural parts of the towers were manufactured by Messrs. Edward Wood & Co., Limited, Manchester; the pneumatic handling machinery, and the tower travelling gear were furnished by Messrs. Robert Boby, Limited, Bury St. Edmund, all of which formed part of the main contract placed in Messrs. Thomas Robinson and Son's hands.

The travelling towers are illustrated in Fig. 20, annexed, and Figs. 21 to 25, Plate XX, Fig. 21, showing a general arrangement from one side, while Fig. 23 is a plan of the first floor and illustrates the disposition of the plant on the tower. Fig. 22 shows the framework only of the tower and mast from the river side. Figs. 24 and 25 show the underframe. Each tower is a steel frame structure running on four small bogies, with a track gauge of 15 ft. The bogie centres are 14 ft. apart, the overall length of the tower base being 21 ft. The base is built up of longitudinals formed each of two 12-in. by 3½-in channels, back to back and 9 in. apart, and top and bottom cover plates 16 in. wide and ¼ in. thick. The main cross-members are similar, while diagonal strutting of 8½-in. channel is also introduced connecting with a main gusset carried by a central cross-member of 8-in. by 4-in. steel joist. On this base is built up the three-storied tower, the main corner members of which are of 6-in. by 3½-in. channel. This is also the section adopted for the main floor members, the vertical and diagonal main side members, &c. Secondary side members are introduced of 4-in. by 4-in. by ⅜-in. tee, 4-in. by 3-in. by ⅜-in. tee and 2½-in. by 2½-in. by ¼-in. angle. On the first floor, Fig. 23, is carried the driving gear, both for travelling the tower, and for operating the short band delivery conveyor, and the bucket wheel of the air lock at the base of the canister. An operators' cabin is built out on one side of this floor as shown in Fig. 22. On the second floor of the tower is arranged the bucket air lock from the canister with some other gear while the canister or receiver itself is carried on the third floor. On the river side of the tower the tall lattice mast consists of two members of 6-in. by 3½-in. channel, extending 24 ft. above the top of the tower proper, spaced 9 ft. apart at the third floor level, tapering to 2 ft. 11 in. at the upper extremity. This mast serves to support the suction pipes, and it is braced back to the tower by diagonals best seen in Fig. 21, showing the side view of the tower.

The bogies are illustrated in Figs. 26 to 31. As will be seen from the drawings, two of these are arranged to swivel in both directions. These two are plain bogies, while the others are driving bogies. The wheels are 28 in. in diameter, of cast-iron with steel tyres, and and are centred 3 ft. 3½ in. apart. In the case of the plain bogies (Figs. 26 to 28) the frame is pivoted on a 3½-in. horizontal pin carried on the bogie centre, the latter having a deep cup into which fits the king pin, a casting 5 in. in diameter fitted with a gun-metal sleeve. The king pin is of cast steel, as is also the centre casting. Gun-metal rubbing plates are provided between the contact surfaces of the upper and lower centre castings.

Details of the driving bogies are shown in Figs. 29 to 31. The drive from the motor on the first floor is brought down to the base by a 3-in. vertical shaft and bevels. In brackets below the base frame is arranged an horizontal shaft $3\frac{7}{16}$ in. in diameter, extensions to which form the swivel centres of the bogie frames on the centre casting. The pinion on this central shaft gears with cast steel tooth rings bolted to the bogie wheels, as shown in Fig. 30. Fig. 23, which shows the first floor of the tower, indicates the position of the main reversible motor, which is of 20 h.p., running at 725 r.p.m. This drives a worm reduction gear, the ratio of which is 41 : 5. From this gear by means of a clutch the drive is transmitted to a bevel in mesh with a corresponding wheel on the vertical shaft previously referred to. This set of gears has a reduction of 3 : 1. The reduction ratio for the bevel drive to the bogie shaft is 39 : 16, while that of the gears on the bogies is 14 : 26, giving a total reduction from the motor to the bogie wheels which results in a travelling speed along the track of 48·5 ft. per minute.

Coming now to the pneumatic equipment of the towers, grain is drawn from the vessels by two suction pipes supported by the tower masts referred to above. These pipes have a working radius at the bend of 33 ft., and vertical range of 20 ft., but the nozzle, being mounted at the end of a vertical pipe fitted with ball joints allowing 30 deg. universal movement, and a length of flexible pipe, has a good deal wider operating range. The vertical pipes are 8 in. in diameter, and the horizontal lengths to the tower 10 in. in diameter, enlarging to 11 in. at the swan-necks, which with ball joints at this point give the pipes universal movement of a considerable range. The bends between the vertical and horizontal sections of pipe are square in section with renewable steel doors. The suspension ropes supporting the pipes are led over pulleys on the mast to counter-balance weights at the back of the tower shown in Fig. 21. Hand-operated hoists are arranged inside the tower, for the vertical adjustment of these pipes. The swan-necks deliver into the conical base of the canister which is 8 ft. in diameter, with a parallel vertical length of 12 ft.

The canister is fitted inside with a dust cyclone, which prevents the dust being carried off by the exhausting main. The latter leaves the canister by a large bend at the top, and is led vertically down from the canister to a level slightly below that of the second floor, where a large radius bend and two flexible lengths of rubber and canvas hose, at the end of which is fitted a flange, enable connection to be made with the gantry main tee pieces. The flexible end of the tower pipes is suspended by a rope carried to a small winch inside the tower.

From the conical discharge end of the canister the grain with the dust returned to it, is delivered to a bucket wheel discharging gear of which drawings are given in Figs. 36 to 40. The discharger, Figs. 39 and 40, has a speed of 20 r.p.m., and is driven from the first motion shaft through the momentum reversing gear illustrated diagrammatically in Figs. 36 to 38,

and also in the plan, Fig. 23. These parts we revert to below. Under the wheel discharger is a chute which delivers the grain on to a 27-in. band conveyor. The outboard end of this conveyor is suspended by a rope carried to a winch in the tower, enabling the end to be raised or lowered as required through a distance of 5 ft. It is used in its higher position when delivering grain, but is lowered to the horizontal for the delivery of sacks. Two speeds are obtained for this conveyor from the first motion shaft, giving a belt speed of 537 ft. per minute for grain, and 141 ft. per minute for sacks. When working with the latter a second chute is used and the chute from the discharger moved to one side. As an alternative method sacks may be lifted from the ship's deck and placed direct on the belt conveyors by the cranes shown in Fig. 20.

The momentum reversing gear is introduced between the main drive and the bucket discharger to prevent damage in case any pieces of wood, rope, iron or any other obstruction should block the discharger. The action will be followed from Figs. 36 to 38. The main drive is taken by gearing to a countershaft, on which are two 24-in. pulleys. From the latter, by means of belts, one open and the other crossed, the shaft shown in Fig. 38 is driven, in the directions indicated by the arrows on the driven pulleys. In this combination are two clutches and a momentum wheel, inside the boss of which is a worm fixed to the shaft, and on which the momentum wheel can travel endwise. The drive to the discharger is from the sprocket at the left-hand end of the shaft in Fig. 38, and if this is checked by reason of a blockage, the momentum wheel continues to revolve and travels to one side or the other as the case may be, de-clutching one drive and engaging the other by means of toggles, thus reversing the discharger. This operation is automatically repeated whenever the drive in one direction is interrupted. The bucket wheel discharger is shown in detail in Figs. 39 and 40. It has an internal diameter of 2 ft. 6 in., with top and bottom openings 1 ft. 4 in. wide by 2 ft. 10 in. long. The wheel has eight blades and compartments. The end bearings are carried in short slides, that for one end being arranged at 90 deg. to that for the other. The joint at the circle of contact of the bucket wheel and container is maintained airtight by means of leather rings.

The vertical suction pipes and flexible ends are illustrated in Figs. 21 and 32, and Figs. 33 to 35 shows the form of nozzle used. This is an adjustable nozzle allowing a supply of air to pass down between the outer sleeve and inner pipe, this air being regulated as required by means of a short length of inner sleeve and diaphragm. When the inner sleeve is lowered right down (Fig. 33) and the diaphragm closed, the suction on the bell-mouth is greatest, the maximum quantity of grain being lifted under these conditions. When the inner sleeve is raised, as in Fig. 35, and the diaphragm open, a larger quantity of air is drawn in below the lower lip, and a minimum quantity of grain is lifted. Fig. 34 shows a plan of the ring and diaphragm at the upper end of the nozzle, with the adjustable air openings.

The pipes are fitted with hinged ball joints which are so clearly illustrated in Figs. 50 to 52 as to require no further description. These joints are actually for the 11-in. pipe at points close to the swan-necks. The ball and socket are struck to a radius of 7 in., and the movement allowed is 30 deg. The hinge pins are 1 in. in diameter.

The swivelling swan-necks are placed side by side at the canister base on radii from the centre of the canister 30 deg. apart. They are shown in detail in Figs. 42 to 46, the plan Fig. 41 giving their relative positions, while Figs. 48 and 49 show the fixed elbow swivelling pins. The upper ends of the fixed elbows are bored to form a socket 13 in. in diameter, into which fit spigot ends on the upper elbow casting, illustrated in Figs. 45 and 46. From a flange on the latter depends a bracket arm of I-section, illustrated in Figs. 48 and 49. This arm has a bush and ball bearing at its lower extremity, as shown in Fig. 48, fitting the pivot pin on the fixed elbow.

The whole plant we have described has many features of much interest and Messrs. Robinson and Son, Ltd., are to be congratulated on the completeness with which it has been carried out.

WATER STORAGE IN BRAZIL.—In connection with its plans for the reclamation of its semi-arid States, the Brazilian Federal Government has retained the services of Messrs. Dwight P. Robinson and Co., Incorporated, engineers and constructors, of New York, to supervise a large amount of engineering and construction work. This work, which is located in the States of Ceara and Parahyba, will include the construction of five large dams—involving nearly a million cubic yards of concrete—to create storage reservoirs, some of which are to be larger than any artificial reservoirs existing elsewhere. The work is to be conducted under the direction of the Brazilian Government, and its ultimate importance and economic value are comparable to the irrigation work carried on since 1903 by the United States Government.

INDUSTRIAL NOTES.

IN anticipation of the opening of the Trades Union Congress at Cardiff, on Monday last, there was a series of meetings on Sunday, addressed by well-known Labour speakers. Mr. Bromley addressed one meeting, Mr. J. H. Thomas another, and Mr. Robert Smillie a third. Mr. Bromley said his society had been so generous in connection with the miners' strike that they now had an overdraft at the bank of 70,000*l.*, and implied that they had received little or no thanks for the assistance they had given. In the future he said they would fight to the last shekel for locomotive men, but he doubted whether they would go further.

Mr. J. H. Thomas, in his speech at a mass meeting, said that the rank and file of labour should not allow itself to be swayed by emotion, and should think things out for themselves. Mr. Thomas spoke of two lines of thought and action in the movement, one advocated by communists who wanted to uproot the whole exising social system by a bloody upheaval, and the other whose object was to use trade union activity and solidarity to the best advantage in industrial matters, and foster comradeship. He also warned his hearers, as he has frequently done of late, against the fallacy that the less work a man does the more there is to be done by others.

The Trades Union Congress opened at Cardiff on Monday, not having met in that city for 26 years. At the previous Congress held at Cardiff there were present some 330 delegates representing about 170 unions with a membership of about 1,000,000. At the Congress held during this week the number of delegates was 823, representing 212 unions of a combined membership of about 6,500,000. After the welcome by the Lord Mayor, the president, Mr. E. L. Poulton, of the Boot and Shoe Operatives' Union, delivered an address, which forms the subject of editorial comment in another column. We therefore shall not refer to it here.

The Lord Mayor of Cardiff, Alderman James Taylor, is, be it noted, a member of the National Union of Railwaymen. His address of welcome to the delegates is therefore interesting, for he criticised the action of men who purposely did not give an employer whole-hearted effort in return for wages received.

A deputation of unemployed waited upon the Congress on Monday. The speakers on behalf of the deputation included Mr. J. W. Holt, Mr. E. Pitt and Mr. J. Maclean. Nothing of an enlightening character resulted from this innovation, the president contenting himself by saying that when Congress reached this subject a resolution would be drawn up aiming at the abolition of the present inhuman system of relief.

The resolution in question was put before the Congress on Tuesday morning, being moved by the president. It is too long for quotation in full, but reaffirms the principle that the State should provide work or maintenance for every willing worker, and that the financial burden resulting from efforts on the part of Guardians to relieve distress should be taken by the Government, and not be placed upon the ratepayers.

The proposals embodied in the resolution imply the spreading out of the cost over a larger number of taxpayers than the ratepayers of any particular district, and some equalisation at least of the charge. How willing some of the present unemployed are to do work may be gathered from the Hackney Workhouse incident recorded elsewhere in this column. It need hardly be said that the resolution was not couched in strong enough terms for several delegates.

The Trades Union Congress continued its session on Wednesday but nothing of great interest arose. The day was taken up with the discussion of matters arising out of the troubles in Ireland, the League of Nations and the stage. It also considered without much result the question of sliding scales for wages. It may be stated that on Tuesday various speakers called in question the official index figures for cost of living, alleging that they were too low. The Ministry of Labour has officially countered these allegations and is preparing a reply for publication in *The London Gazette* in due course.

In view of meetings next month regarding further 12½ per cent. reduction in wages, some engineering firms are already lowering their quotations by this amount. This fact should afford proof to the employees that the reduction is honestly desired in order to obtain trade, and not in order to make larger profits.

In a letter to the Editor, published in *The Times* of the 2nd inst., Sir A. F. Yarrow draws attention to the fact that high costs during the war and at the present time have been due to different causes. During the war the cause was shortage; at the present time the cause is high wages, and not shortage, and the same remedy, therefore, cannot be applied in the two cases. The remedy applied during the war was to increase wages, but to do that now would aggravate the situation and a fall in the necessaries of life will only be possible when wages drop generally.

As a sequel to the recent coal strike Mr. W. Adamson, secretary of the Fife Mineworkers' Union, waited on the Scottish Board of Health in Edinburgh on Friday last in connection with the destitution of the Fife mining communities. Mr. Adamson stated that the Miners' Association had exhausted the whole of their resources and that he had written to the Coalowners' Association and to the Secretary of Mines suggesting that their allotment of the Miners' Welfare Fund should be made available to save the people from absolute starvation.

The present difficulties of the engineering industry were referred to last week by Mr. E. W. Petter, at the annual shareholders' meeting of Messrs. Petters, Limited, Yeovil. Mr. Petter stated that they had endeavoured to find a suitable industry to replace aircraft work, but had failed owing to the trades unions concerned refusing to accept any system of payment by results under which alone such an industry could have been successfully carried on. The result was that the works had been maintained with only a nucleus staff at considerable temporary loss. The high rate of wages, and even in a greater degree the trades union restrictions with regard to apprentices, labourers and semi-skilled labour, and the shorter hours, resulted in engine parts which cost a few pence before the war costing as many shillings to-day. He felt that if they could talk direct to their men instead of having things settled for them by conferences in London, most of their difficulties could be settled satisfactorily.

In connection with the industrial outlook the following facts given on the authority of a Peking correspondent of *The Times* are instructive: The result of tenders for railway material has recently been published. For locomotives of the "Prairie" type the successful Continental tenderer quoted 10,000*l.*, against the lowest British tender of 13,000*l.* For "Mikado" locomotives an American tender was 12,500*l.*, against the lowest British of 14,900*l.* For steel open wagons the Continental firm which was successful quoted 680*l.* each, while the lowest British tender was 1,016*l.*, and so on. These figures are of interest in view of Sir A. Yarrow's letter to *The Times* quoted in this column.

In connection with the action taken in London by the unemployed to secure high rates of relief it is interesting to note that at the North London Police Court the magistrate last week had before him 21 men who, when admitted to Hackney Workhouse and given board and lodging, refused to perform the customary work demanded in such cases. The magistrate sentenced seven of the men to seven days with hard labour; the remaining 14 decided to do the work allotted to them.

It is announced from Manchester that the Co-operative Wholesale Society, which recently decided upon a 10 per cent. reduction for its employees, of which 5 per cent. took effect on August 22 and the remainder to take effect this month, will enforce the second reduction of 5 per cent. on September 26, in spite of representations made by the employees' union.

The S.S. Berlin of the North German Lloyd was taken over by the White Star Company in November last. She has now been renamed the Arabic, and after refitting has sailed on her first voyage under her new owners to New York. The refitting of the Arabic should have been done at Southampton, while that of the Suevic was to have been done at Liverpool. Troubles at both these ports resulted in the work being transferred to Portsmouth. It is now stated by the White Star Company that this entailed wages lost to the homes of the crews of these vessels amounting to about 75,000*l.*, while labour at the two ports lost about 100,000*l.* In this case, of course, this money was simply diverted from one port to another, but in numerous instances in recent months, the same causes have resulted in the work going out of the country to Cherbourg, Hamburg, Antwerp, &c.

Speaking at the luncheon given at the opening of the Shipping, Engineering and Machinery Exhibition at Olympia last Wednesday, Sir Trevor Dawson stated that when in Germany about a month ago, he had had the opportunity of investigating the labour question in two large establishments, one an electrical works and the other a leading steel and engineering works. He "found that both these works were hives of industry, that labour appeared to be working

harmoniously and that output was very high." At the electrical works the shops and machinery had been written down so that they stood in the books at the value of 1 mark. The absence of any taxes such as the excess profits duty or the munitions levy had permitted industrial undertakings to collect working capital, and so to take an excellent economic position to compete successfully in the markets of the world. The average wages for an eight-hour day were 4 marks per hour, equal to about 3*d.* per hour at the present rate of exchange. When this was compared with the average rate of 1*s.* 9*d.* per hour in British factories, the handicap under which we laboured would be evident.

At one of the largest engineering works in Germany Sir Trevor Dawson had enquired as to the class of workshops which were erected during the war to cope with the demand for munitions. In reply to his question he was shown one of the most perfectly designed and equipped locomotive works in the world. The shops were arranged in rows, so that raw material entered at one end, and the locomotive was finally completed in the last shop ready to proceed to its work on the railway. He was informed that this factory had been specially designed for the most economical production of locomotives, but during the war its function was to increase the output of heavy gun mountings. This showed clearly what was in the minds of the Germans even during the war, and how thoroughly they studied and how clearly they foresaw the economic position which would arise when the war was over.

The depressed condition of commerce at the present time could, in Sir Trevor Dawson's opinion, be largely attributed to the question of the rates of exchange, and the most important commercial question to be settled to-day was undoubtedly the problem of exchange. Every endeavour must, he considered, be directed to meet the economic situation which now confronted the trading nations. With this everyone will agree, but the speaker gave no indication whatever as to how the exchanges could be rectified. The "lowering of the cost of mass production, combined with the improvement of exchange will alone enable us to compete with the favourable economic conditions existing at the present time in other European countries" was Sir Trevor's summing up of the situation, and he expressed "every confidence in the commonsense and foresight of our workmen in co-operating to enable the country to attain this desirable aim."

OIL FUEL ON SHIPBOARD.

TO THE EDITOR OF ENGINEERING.

SIR,—I have been studying the latest rules of the Board of Trade having reference to the application of oil fuel for use aboard ship, and I am struck with the careful provision which has been made so far as storage and safe isolation of oil is concerned, but I fail to discover any rule which would afford protection to the *personnel* of the boiler room. The rules are quite clear and definite regarding the pressure the oil fuel pipes and other units should be capable of resisting under test, but after that the affairs of the stokehold are left to the engineers and boiler attendants to see things through safely.

I had occasion to visit a Liverpool liner last year, when I found that there was only a single pump to depend on for the supply of oil fuel between the bunkers and a daily supply tank from which oil is drawn to serve the furnaces. Two sets of apparatus provided with pumps for withdrawing oil fuel from the daily supply tank and delivering it through the heaters and filters and thence to the furnaces were fitted as per rule (one of these being for stand-by purposes), but absolutely no provision was made to ensure either or both of these pumping and heating sets to draw direct from the bunkers in the event of the pump used for drawing oil from the bunkers and delivering to the daily service tank failing to function, and therefore if by any chance this transfer pump failed, the supply of oil to the fires would very soon cease and thus the boilers would go out of commission, and the ship would therefore be out of commission.

It is perhaps an oversight that the rules do not state that suitable provision should be made so that either of the pumps connected with the oil fuel heaters shall be capable of drawing from the bunkers. I referred to this in the *Journal of Commerce* of July 29, 1920, but the matter has evidently been overlooked, as I find that in the interval at least one important passenger ship has been equipped exactly in the way referred to, and it is high time that such matters should receive attention before trouble occurs.

What would be the outcome if a passenger ship went ashore in a gale owing to the failure of a transfer pump? Would the captain and chief engineer have to defend their "tickets" because the Board of Trade had overlooked the point mentioned, or would the Board of Trade be solely to blame? Fog is bad enough to contend with at sea, but seeing that there are ships equipped as I describe, and which have been passed by the Board of Trade Survey as to fitness for service, it would be wrong to attach blame to any officer for anything which might happen to the ship because of any oversight of the Board of Trade.

What I have referred to above constitutes a part only of what needs attention. When it is considered that in addition to pipes, valves, pumps, heaters and filters being able to withstand pressure and that all flanges and joints will be of a suitable and serviceable character, there are quite a few other things which call for consideration and which the Board of Trade have evidently overlooked, and one of these concern certain units which should be so designed that they will ensure reasonable certainty of continuous service without interruption or pause even in the face of some neglect, and it is my opinion that the Board of Trade have in several cases passed as satisfactory units which I very much doubt would satisfy the condition I mention. Further, since the rules provide for all valves to have bolted-on covers so that when operating the valve there will be no slacking back of the cover and thus afford the possibility of a leakage of oil, it would have seemed reasonable if in the same rule it had been provided that no valve should be fitted (as I have seen them in at least one instance) over the furnace front, as if a flange joint gave out, oil leaking on to a hot plate might cause a fire where a fire is least useful, and the valves under such circumstances could not be operated.

There would be some warranty for the exact rules which apply to the bunkers and their careful isolation if the same carefulness was exercised in an endeavour to cut out the possibility of fire by giving more attention to the detail of boiler equipment and insisting that important trifles such as the placing of valves over furnaces would not be allowed and that such measures as would tend to diminish, if not entirely eliminate, back-firing got some consideration.

At the moment there are ships equipped for oil-firing where no such provision has been made and where there is nothing to check or prevent flame (as the result of back-firing or of the bursting of a boiler tube) coming into the stokehold. In many cases there is little or no command over the burners as they lack the means of regulation, and this no doubt accounts in most cases for back-firing where it occurs.

Having spent half a lifetime in developing the means of employing oil fuel for steamship use it is novel for me to witness something of the happenings and to inspect some of the jobs which have been passed by the Board of Trade. The same honourable Board which makes it imperative to carry a sufficiency of lifeboats and lifebelts should at least see to it that, when one elects to cross the ocean, there should be a certainty of good steam throughout the whole trip, and with the same certainty of an uninterrupted passage back if this can be assured with the aid of good, reliable and sufficient appliances.

With regard to that portion of the rules relating to the flash-point of the oil and that this shall not be below 150 deg. F. (closed test), I venture to say that something might have been added to prevent, as far as possible, the chance of oil fuel containing a high percentage of water being delivered, as, where the percentage of water is great, the oil is dangerous to use and causes damage to the boilers.

Yours faithfully,
J. J. KERMODE, M.I.Mech.E.
35, The Temple, Dale-street, Liverpool,
September 3, 1921.

THE JUNIOR INSTITUTION OF ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—As a provincial member of the Junior Institution of Engineers, I have read with interest your recent leading article "The Younger Men" and the correspondence which has arisen out of it.

May I suggest that much of the criticism is due to somewhat imperfect or at best but a partial acquaintance with the factors involved? Undoubtedly the most important of the recent proposals are the financial ones.

As chairman of the North-Western Section of the Institution, it has fallen to my lot to deal pretty thoroughly with the problem of adjusting financial obligations to income-producing resources, but personally, I think the council were somewhat unfortunate in their ultimate decisions. Would it not be better to revert to the traditional classification of members and divide them into those resident within and without the London area in the first place and then grade them into senior members and members, a limit of age being the line of demarcation?

Yours faithfully,
September 5, 1921. GEO. W. CUSSON.

TO THE EDITOR OF ENGINEERING.

SIR,—Every member of the Junior Institution of Engineers who has the welfare of his Institution at heart will, I feel sure, sincerely thank you for your appreciation and the kindly inspiration that prompted the leading article on August 12. The letters which have followed from well-known members of the Institution, express opinions which are based on years of experience.

I have been a member for over twenty years and have the happiest recollection of my association with its activities, both instructional and social, and I am in a position to say that the work of the Institution is appreciated by very many members outside the London area. The evidence of this is the gradual but healthy growth that has taken place during the last decade of local sections, in Manchester, Sheffield, Newcastle-on-Tyne, Plymouth, Birmingham, &c., in this country, and even as far afield as India and Australia.

This world-wide aspect of the Institution's work is of the utmost importance when viewed from a national point of view, helping as it does to cement the ties of Empire in those who will, in future years, take their places in the ranks of the seniors in the profession.

As the Institution grows older the average age will rise to a point when it will doubtless remain fairly stationary, and there is the danger that the young engineer for whom the Institution undoubtedly primarily exists, may not always be *prima facie* in the deliberations of those into whose hands the reins of management are placed, and unintentional as this is, your leading article is all the more valuable, and should be received with the grateful consideration which is undoubtedly its due.

Yours faithfully,
R. B. ASKQUITH ELLIS.
Local President, Midland Section, J.I.E.
September 6, 1921.

DOUBLE REDUCTION GEARS.

TO THE EDITOR OF ENGINEERING.

SIR,—We have heard a lot lately of failures or unsatisfactory experiences with double-reduction gearing in marine installations, and some very interesting investigations have been made on this question. We have two papers on the subject read before the Institution of Naval Architects, one by Engineer-Commander Tostevin, D.S.O., on "Experiences with Gearing on Warships," the other by Messrs. R. J. Walker, C.B.E., and S. S. Cook, B.A., of the Parson Marine Steam Turbine Company, Limited, on "Mechanical Gears of Double-Reduction on Merchant Ships."

Now it always seemed to me that a want of accurate balance of gear wheels, be it ever so slight, especially of the intermediate wheel, which has comparatively a large mass, and runs very fast, would have a very bad influence on the wear of the system, and would greatly increase the strain on the teeth.

I was over in Germany last month and visited one of the largest tool works there.

This firm has recently attached great importance to balancing rotating parts. Their engineer told me that they now balance every shaft and layshaft of the lathes they build, and do the same with all gear pinions, clutches, pulleys, &c., mounted on them. The results have been so gratifying, that they would never think of building anything again without balancing every revolving part. The vibration and noise set up formerly by the transmission when running, they had always ascribed to the more or less imperfect tooth form of the machine-cut gearing, but now after balancing, they find the vibration and noise have disappeared, proving that it was not the imperfect tooth shape, but the unbalance of each shaft with its pinions, &c., which set up the noise and vibration. The driving motor armatures are also balanced, and they find the lathe now requires appreciably less power to drive it. It is natural therefore to expect the wear to be greatly diminished so there is a great gain all round. Motors thus balanced could now probably be fitted on the lathe headstock without the vibration influencing its running.

From this it would seem that balance has more to do with the satisfactory running of gears than the actual degree of perfection of their teeth. Where the teeth of a marine reduction gear system have been cut on the "creeper" system they are probably of a far more perfect shape than most lathe-transmission gear teeth. It seems to me, therefore, quite likely that the trouble may have been as often due to want of balance as to any other not yet detected reason. I realise, of course, there are other conditions in the working of a marine gear than are met with in the case of lathes. Account must be taken of the outside influences acting on the propeller, the variations in the shaft torque, &c., but it is quite conceivable that an investigation in this direction might lead to some very encouraging results.

I am, Sir, yours faithfully,
W. H. MARTIN, A.M.I.N.A.
Vauxhall, September 1, 1921.

ON CONSTITUENTS FOUND IN TUNGSTEN AND MOLYBDENUM STEELS.*

By ALBERT M. PORTEVIN (Paris).

THE practice of annealing, followed by exceptionally slow cooling, is one of extreme interest from the point of view of researches on the structure of special steels. Such treatments not only afford a means of securing a general enlargement of the structural features, so as to allow of a closer scrutiny of their details and peculiarities, but also lead to true states of equilibrium being obtained. By adopting this mode of systematically investigating the special steels the author has been able to effect not only the disappearance of obviously hard states (martensitic or austenitic) hitherto observed exclusively in certain chromium and manganese steels,† but has been also able to establish the fact that certain structures which might have been regarded as being in equilibrium, are superseded by others which, by the separation of constituents not hitherto described, represent, in the sequel, an even more advanced state of equilibrium.

Examples, in the case of certain tungsten and molybdenum steels, will be described. The author would wish to point out, however, in this connection that nickel steels, or, at any rate, those which he has studied by this method, containing up to 30 per cent. of nickel and 0 per cent. to 0·8 per cent. of carbon, undergo profound modifications in structure, but that the new structures thus created are complex, and that their interpretation presents very great difficulties, owing to the uncertainty surrounding our knowledge of the stable iron-nickel system. Indeed, even the knowledge and insight of F. Osmond, to whom in 1912 the author submitted these

* A Paper contributed to the Paris meeting of the Iron and Steel Institute, September, 1921.

† A. Portevin, "Comptes Rendus," 1911, vol. cliii, p. 64; 1917, vol. clxv, p. 62. Assoc. Inter. des Essais Matériaux, November, 1911.

structures, failed to find an explanation of them. For this reason the author has himself forborne to describe them, and has limited himself hitherto to a description of the variations in electric resistance which accompany them.*

1. *Tungsten Steels.*—An investigation of the structural variations resulting from annealing tungsten steels and then cooling them extremely slowly, has led the author to the following conclusions, amongst others, in regard to alloys containing from 0·1 per cent. to 0·4 per cent. of tungsten. The structure of these "normal" steels is described as consisting of ferrite associated with pearlite (Guillet, Swinden), or even as being devoid of pearlite (K. Honda and T. Murakami). After annealing at about 1,300 deg., followed by a cooling extending over 75 hours, down to 200 deg., the structure is completely altered. Fig. 1 shows a steel containing 0·4 per cent. of carbon and 5·4 per cent. of tungsten which has undergone this treatment. There will be observed a network formed that this limit must be extended to low percentages of tungsten.

In addition to the foregoing there are to be observed, in these steels, white areas of ferrite (solid Fe–Fe_2W solution), the proportions of which diminish as the carbon percentage increases, and a carbide (which, according to K. Honda and T. Murakami, is WC) either in visible particles more or less coalescent or forming part of a troostite readily stained by acid reagents. Once obtained, this special acicular constituent persists even if these steels be subjected to fresh annealings at about 1,000 deg. C. On the other hand, by annealing at 1,100 deg. (and cooling for a period of 3½ hours) the carbide can be made to disappear and only ferrite and the acicular complex remains in steel low in carbon (Fig. 4). The entire solubility curve of Fe_2W in the solid state requires to be extended in the direction of the low percentages of tungsten.

To sum up: in tungsten steels a structure comprising

Our knowledge relating to the equilibrium of the iron-molybdenum system is confined actually to the hypothetical pseudo-binary diagram plotted by Lautsch and Tammann, which allows of the existence of a compound X, which forms slowly but increases with the temperature attained. On the other hand, Vigouroux, basing his results on the analyses of the residues from etching with hydrochloric acid, concluded that four compounds were present, one of which was Fe_2Mo. The investigation, by chemical methods, of the constitution of alloys has, however, often proved fertile in putting forward compounds which have subsequently been found to have no real existence. In these circumstances, and taking into consideration the much smaller number of observations, it is not possible to draw definite conclusions as to the chemical nature of these acicular needles, which may be either an iron-molybdenum or an iron-carbon molybdenum compound. Whichever they may be, the similarity between these structures in tungsten and in molybdenum

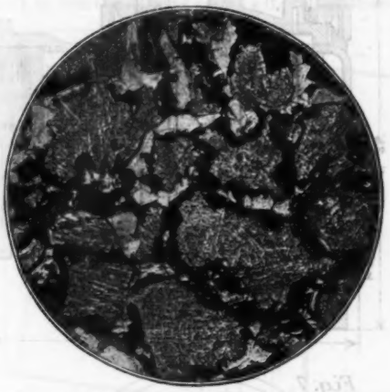


FIG. 1. TUNGSTEN STEEL (C = 0·4; W = 5·4 PER CENT.). ANNEALED AND VERY SLOWLY COOLED. ETCHED FOR 1 MIN. WITH BENEDICK'S REAGENT. × 30.

FIG. 2. TUNGSTEN STEEL (C = 0·4; W = 5·4 PER CENT.). ANNEALED AND VERY SLOWLY COOLED. ETCHED FOR 1 MIN. WITH BENEDICK'S REAGENT. × 870.

FIG. 3. TUNGSTEN STEEL (C = 0·4; W = 5·4 PER CENT.). ANNEALED AND VERY SLOWLY COOLED. ETCHED FOR 4 MINS. WITH SODIUM PICRATE. × 200.

FIG. 4. TUNGSTEN STEEL (C = 0·1; W = 5 PER CENT.). ANNEALED AND VERY SLOWLY COOLED; THEN ANNEALED AGAIN AT 1100 DEG. AND COOLED FOR 3½ HOURS. ETCHED FOR 2½ MINS. WITH BENEDICK'S REAGENT. × 200.

FIG. 5. MOLYBDENUM STEEL (C = 0·5; MO = 1 PER CENT.). ANNEALED AND VERY SLOWLY COOLED. ETCHED FOR 10 MINS. WITH SODIUM PICRATE. × 200.

FIG. 6. MOLYBDENUM STEEL (C = 0·5; MO = 1 PER CENT.). ANNEALED AND VERY SLOWLY COOLED. ETCHED FOR 10 MINS. WITH SODIUM PICRATE. × 600.

of light and dark areas separating regions occupied by a constituent differing from any hitherto known. This is apparently a complex consisting of needles, and is met with alike in steels with a lower carbon percentage (0·1), and in steels with a higher tungsten percentage (7·55). Examined under high magnification there can plainly be seen needles arranged (Fig. 2) similarly to those of the martensite of hardened steels. These needles can be coloured by a solution of sodium picrate in soda (Fig. 3). This characteristic, added to their abundance in steels with so low a carbon content (which prevents them being taken to be carbides) shows them to be a tungstide, Fe_2W. The arrangement of the structure (Widmanstaetten) shows them to have separated gradually from a crystallised medium, which is the solid solution Fe-Fe_2W. Now, in the iron-tungsten diagram the regional limit of this solid solution, that is to say the solubility line of Fe_2W in the solid state, is a curve showing a decreasing solubility as the temperature rises, and ending at 9 per cent. of tungsten at ordinary temperature (K. Honda and T. Murakami). The presence of the acicular complex ferrite + Fe_2W in steels with 0·1 per cent. of carbon and 5 per cent. of tungsten proves four constituents is encountered: a tungstitic ferrite, a tungsten carbide, a tungstitic troostite, and a new constituent which is a complex ferrite + Fe_2W. This amounts, however, but to three phases: solid Fe–Fe_2W solution, WC, and Fe_2W, which is compatible with the equilibrium of the Fe–W–C system.

2. *Molybdenum Steels.*—The author has succeeded in finding in molybdenum steels annealed as previously described a constituent presenting the same morphological characteristics and susceptibility to etching as the acicular complex just described in connection with tungsten steels. Instead, however, of occurring as it does in the steel containing 0·4 per cent. of carbon and 5 per cent. of tungsten, in masses regularly distributed and forming the interstitial packing between a network of carbon complex, this constituent is found in irregularly disseminated clusters in a ground mass very readily colourable by acid reagents and hence more highly carburised. These clusters are, moreover, visible to the naked eye owing to the considerable enlargement of the scale of the structural arrangement, resulting from the very slow cooling.

The appearances are identical. It is only necessary to compare Figs. 3 and 5, which show very fine needles distributed according to the Widmanstaetten structure, and colourable by sodium picrate (Figs. 5 and 6).

steels has appeared to the author of interest to record, the more so as the presence of these constituents indicates a state of equilibrium more stable than that previously encountered.

IRREGULARITIES IN TENDERS FOR BELGIAN GOVERNMENT CONTRACTS.—The Commercial Secretary to His Majesty's Embassy at Brussels (Mr. B. P. Sullivan) reports that the Belgian Minister of Public Works has recently called the attention of the Administration des Ponts et Chaussees to the fact that tenders for contracts are frequently accepted in the interests of the Treasury despite the fact that they deviate from the prescriptions laid down in the specification in respect of the materials to be used. The Minister is, however, of opinion that if this practice becomes general, miscalculations will result, and a proper adjudication of public contracts will be made difficult. He has consequently directed that a clause shall in future be inserted in specifications to the effect that contracting parties are particularly reminded that any tender which does not conform with the prescription of the specification will be considered null and void. It is further stated that if irregular tenders are submitted despite this warning, it will be permissible to make use of them in the examination of similar undertakings.

* A. Portevin, "Comptes Rendus," 1921, vol. clxxii, p. 445.

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

THE Shipping, Engineering and Machinery Exhibition which was opened at Olympia on Wednesday last covers, as its name would imply, a wide variety of products, and the collection which the building now contains is sufficiently diverse to justify the somewhat comprehensive title. The various sections, moreover, are fairly well balanced, so that the visitor, while usually finding enough examples of the commoner articles to enable a comparison to be made, is not surfeited with a multiplication of exhibits of any particular type of machinery. Any misgiving which may have been felt as to the patronage which the Exhibition would receive from manufacturers on account of the depression of trade does not appear to have been justified. Possibly the anxiety to share in what few orders are being placed at the present time has outweighed the natural reluctance to incur the fairly heavy expenditure entailed in exhibiting, but however this may be, a very representative list of manufacturers are displaying their products. It is true that one misses certain firms, but the fact that the whole of the floor space both of the main hall and the annexe are well filled and that there are a good many exhibits in the galleries, shows that there is nothing much to complain of as regards patronage. In the last Exhibition of the kind, which was held in 1919, a considerable section of the main hall was given over to Dutch exhibitors, but this year there is no such concerted foreign display and, with few exceptions the 300 or more stands are occupied by British firms.

As an additional attraction to engineers, lectures will be given and papers read, dealing with matters of technical interest. It is noteworthy that among the subjects for discussion problems connected with the use of oil for marine propulsion or for power purposes are largely predominant. Sir Westcott Abell will deal with "The Immunity from Fire on Oil-Driven Ships"; Engineer-Commander F. T. Addyman with the "Comparative Costs of Oil and Coal"; Mr. James Richardson will discuss "The Progress of the Motor Ship," and other authors take up other questions concerned with oil fuel. In the Exhibition itself the importance of oil as a fuel for boilers or for direct use in internal-combustion engines, is reflected in the various pumps, burners, engines, &c., devised to use it, but there is no undue preponderance of oil apparatus. Shipping is represented in the Exhibition chiefly by photographs and models, the ship models shown by Messrs. Yarrow and Co., Limited, of Scotstoun, being particularly noticeable. The same firm exhibit a model Yarrow boiler, fitted for oil-burning and capable of evaporating 125,000 lb. of water per hour. Messrs. R. and W. Hawthorn, Leslie and Co., Limited, of Newcastle, also show numerous models of ships built and engined by them, for passenger, cargo and war service. Engineering and machinery are such comprehensive terms that it is somewhat difficult to specify the class of exhibits which might be considered most representative of these branches. Ships auxiliary machinery, boilers, pumps, refrigerating machinery, air compressors, small lighting sets, &c., are well distributed throughout the hall, and semi-raw material such as copper and brass tubes, extruded metal of great variety of sections, die-castings and so on are well in evidence. Machine tools are shown by Messrs. William Muir and Co., Limited, Manchester, who exhibit their patent puncher slotter, and its modification as a gear-generating machine. The Tangent Tool Company, Limited, of Keynsham, Somersetshire, have a small universal grinding machine of attractive design on their stand, but their principal exhibits are small rotary shears, both hand and power operated. These have been already illustrated in our columns, their special feature being that flat or corrugated sheets of unlimited size may be cut easily and rapidly. As regards what may be termed engineers, stores of all kinds it is needless to say that they are to be found in great abundance on many stands.

The Parsons Motor Company, Limited, of Town Quay Works, Southampton, are exhibiting vertical enclosed paraffin engines of 60 h.p., 28 h.p. and 14 h.p., arranged for various duties. The largest engine, which is of the four-cylinder type, is direct-coupled to a 30-kw., 230-volt Crompton dynamo, the combined set being designed for lighting or power purposes. The 28-h.p. engine, also of the four-cylinder type, is fitted with standard flywheel, clutch and positive reverse gear, all mounted on angle steel bearers with propeller shaft, stern tube and propeller, so as to constitute a complete marine power unit. The smallest engine, which has cylinders

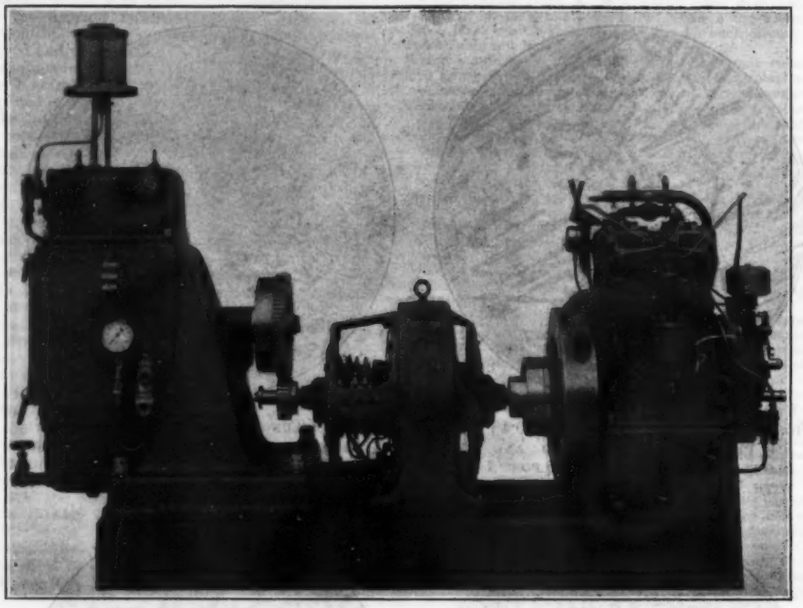
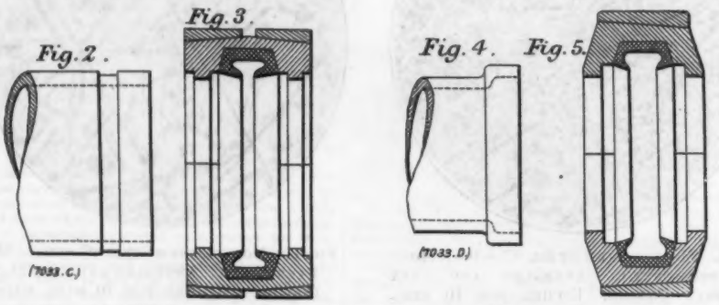
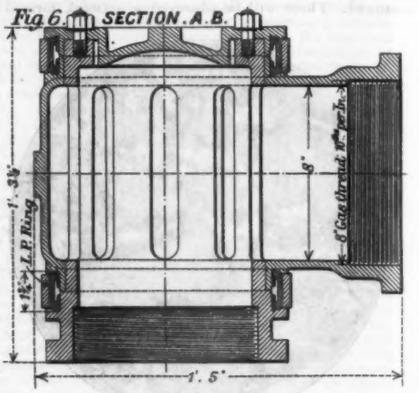
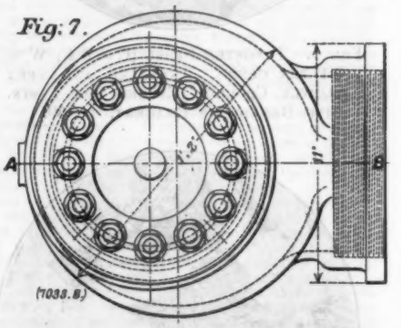


FIG. 1. AUXILIARY PLANT FOR OIL-DRIVEN VESSELS; THE PARSONS MOTOR CO., SOUTHAMPTON.



FIGS. 2 TO 8. VICTAULIC JOINTS FOR STRAIGHT AND SWIVELLING PIPES; THE VICTORY PIPE JOINT CO., LIMITED, LONDON.





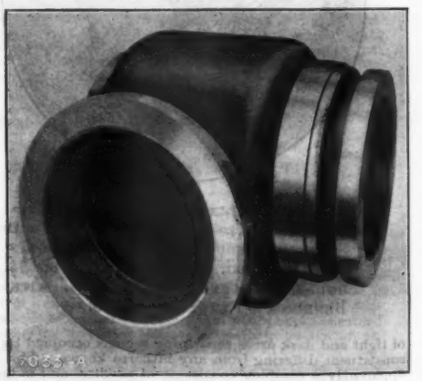


FIG. 8.

4½ in. diameter by 6 in. stroke, is direct coupled to a 7·5-kw. Crompton dynamo of 100 volts to 160 volts, and also drives a Reavell two-stage compressor through gearing. The complete plant, which is illustrated in Fig. 1, on page 374, is mounted on a continuous bedplate. Sets of this kind are practically useful on board Diesel-engined ships, the compressor being used for charging the starting bottles and the dynamo for battery charging, ship-lighting, &c. The compressor which runs at 400 r.p.m., has a piston displacement of 25 cub. ft. per minute, and can be put out of gear when not required by sliding the motor pinion out of engagement. It is of the two stage type, deliver air up to 200 lbs. pressure. The extreme overall length of the set is 8 ft. 1 in. and the extreme height 4 ft. The Parsons engines, which have been fully illustrated in these columns, are built in standard sizes up to 90 b.h.p. The makers have carried out lengthy experiments with engines running on alcohol or alcohol mixtures, and have now placed on the market a type of engine specially designed for use with fuels of such kinds.

The Victory Pipe Joint Company, Limited, of 28, Victoria-street, S.W. 1, have done a considerable amount of development work in connection with their system of pipe jointing which we noticed at the time of its first appearance at the Shipping Exhibition two years ago. The "Victaulic" joint as it is now called, consists, it will be remembered, of a flexible double-U ring, into which the ends of the pipes are inserted. Surrounding the U-ring is a metal housing made in halves, which protects the U-ring and also usually engages with grooves in the pipe ends, preventing longitudinal displacement of the latter. Tapered wedge rings embrace the halves of the housing and hold them together. The arrangement is illustrated in Figs. 2 and 3, page 374. Various modifications are made to suit particular conditions. When a very heavy end pull is liable to come on the joint, the pipes terminate in short enlarged parallel ends, internal flanges on the keep rings engaging with the shoulders of the swivel joint for an 8 in. oil pipe line. The swivelling part is capable of free rotation through a full circle, and the joint is sealed against leakage by means of a pair of double U-rings, as shown in Fig. 6. The construction is sound and ingenious, as will be seen from the illustrations, which are clear enough to render further description unnecessary.

A further application of the principle is illustrated in Figs. 9 to 12, annexed. The steel barrel shown is made in two halves, the circumferential joint round the centre being rendered tight by an expanding leak-proof ring. The half-barrels are made from 12 S.W.G. mild steel plate, and are held together by clips of the same material, with bosses for the bolts welded on. The heavy beading round the edge of the half-barrels stiffens the latter, and forms at the same time shoulders to locate the clips and to support the triangular leak-proof ring. A barrel as shown has a capacity of 40 gallons and weighs 128 lb. when empty. The obvious advantage of the design is that the barrels can be readily taken apart and nested for transit when empty, thus greatly reducing the space occupied, and effecting a corresponding saving in freight. The appearance of the complete barrel is shown in Fig. 11, and that of the two halves nested, in Fig. 12, the joint being of a slightly different pattern from that illustrated in Fig. 8. The overall length of a single barrel is 35 in., and in the same space the parts for four barrels can be contained when the latter are nested. Ten and one-half nested barrels occupy only the space of two whole ones, and seventeen nested barrels will take up no more room than three whole ones. Barrels of this kind are being put on the market by the Kenward Collapsible Steel Barrel Company, Limited, of 15, Tokenhouse Yard, Lothbury, E.C.

The London Electric Firm, of Croydon, whose principal display consists of searchlights, are showing a new type of flexible shaft coupling, the construction of which will be readily understood from Fig. 13, subjoined. The two halves of the coupling, which are keyed in the usual way to the ends of the shafts to be connected, are very much of the ordinary flange-coupling type, but instead of being bolted solidly together, each carries three pins, projecting from its inner face. The pins of one-half of the coupling are connected to those of the other half by laminated links, consisting of thin steel stampings, interleaved together. The links are held together by nuts on the pins, ample clearance for the nuts being cored out by the coupling faces. The external nuts which hold the pins are protected beneath the overhanging shrouding in the usual way. The flexibility of the links will obviously permit a certain want of alignment, or "breathing" of the coupling without imposing any appreciable strain on the shaft or its bearings. Couplings of the type in question are built to suit shafts from ⅜ in. to 2½ in. diameter, and are designed to transmit from 0·3 h.p. to 14 h.p. per every 100 r.p.m. of their speed, the overall dimensions of the arrangement being much the same as those of a solid coupling.

(To be continued.)

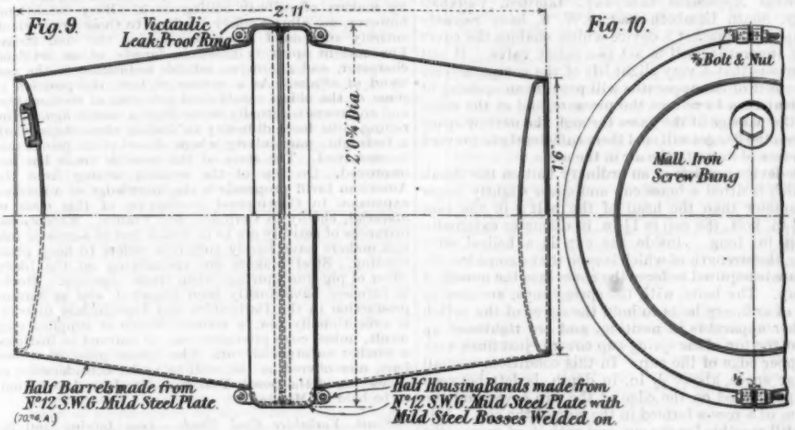


Fig. 9.
Victaulic Leak-Proof Ring
2' 11"
2'0¾ Dia.
1'6"
Half Barrels made from N°12 S.W.G. Mild Steel Plate.
Fig. 10.
⅝ Bolt & Nut
Mall. Iron Screw Bung
Half Housing Bands made from N°12 S.W.G. Mild Steel Plate with Mild Steel Bosses Welded on.

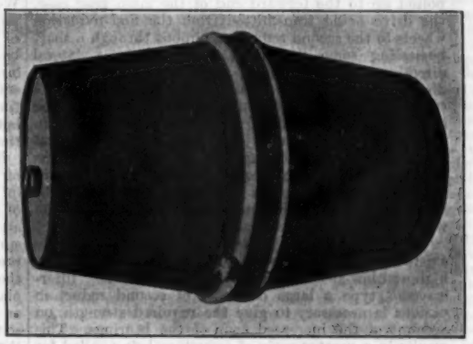


FIG. 11.

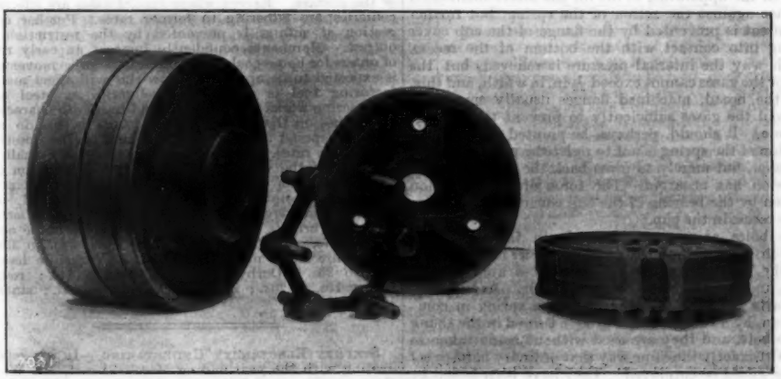


FIG. 13. FLEXIBLE SHAFT COUPLING: THE LONDON ELECTRIC FIRM, CROYDON.

FIG. 12.

FIGS. 9 TO 12. COLLAPSIBLE STEEL BARREL: THE KENWARD COLLAPSIBLE STEEL BARREL CO., LIMITED, LONDON.

DOUBLE-REDUCTION GEARING OF THE THREE-CASE TYPE FOR STEAMSHIPS.

In the double reduction gearing illustrated on page 378 there are three separate gear cases, and the arrangement is considered to possess certain advantages over the usual "interleaved" type where relatively large powers are being transmitted. This gearing has been constructed by Scotts Shipbuilding and Engineering Company, Limited, Greenock, for a single-screw vessel, and transmits 6,000 shaft horse-power. The revolutions per minute of the high-pressure and low-pressure turbines are 3,000 and 1,800 respectively, and the gearing is designed to drive the propeller shaft at 100 r.p.m.

As will be seen from the illustrations, notably Fig. 1, which shows the gears with the cases removed, the first reduction gears are contained in separate cases, bolted up to the forward end of the main gear case, the drive being transmitted from the first-reduction wheels to the second reduction pinions through a shaft possessing some flexibility, especially in a lateral direction; the possibility of trouble arising from distortion of the gear due to straining of the ship's structure is thereby reduced. This flexible shaft at the same time accommodates itself to the variations in direction of pressure on the bearings for the first reduction wheels and the second reduction pinions without affecting the even engagement of the teeth. This construction enables the component parts to be made lighter in weight and easier to handle, and the weight of the installation as a whole is reduced.

With the arrangement it is found that greater latitude exists for fixing the relative amount of reduction in the high and low-speed gears respectively. In the "interleaved" type a large diameter of second reduction pinions is necessary to give the required strength, on account of the increased span of the bearings. This results in a greater ratio of reduction being called for in the first reduction gears. In the three-case type no deep gap is required in the main gear wheel, and the danger of distortion due to the load on the teeth is thus minimised. It may be noted further that as compared with the "interleaved" type, the first reduction pinions require no extensions to connect them with the turbine flexible couplings. The total length overall of the three-case type of gearing is greater than required for the "interleaved" gear, but it will be seen from the illustrations that the space between the first reduction gear-case is conveniently utilised for the main thrust block and the bilge and sanitary pumps which are driven from the gearing. In this connection it may be observed that the size of thrust shaft and collar is smaller than it would be if placed at the after end of the gearing, the reason being that they do not transmit the driving torque.

THE INSTITUTE OF TRANSPORT.—We are informed that the second Institute dinner which was to have been given in April last will be held in the Victoria Hall of the Hotel Cecil, London, W.C., on Monday, October 10, at 7.30 p.m. Prior to the dinner the president, Lord Ashfield of Southwell, will receive the members and guests. Applications for tickets should be made to the Hon. Secretary, Mr. H. E. Blain, C.B.E., 2 and 3, The Sanctuary, London, S.W. 1, not later than October 4.

PERSONAL.—The Scottish Tube Company, Limited, of Glasgow, announce that they have now opened an office and warehouse at 44, Victoria-road, Holbeck, Leeds, where they will carry a large stock of their products.—Mr. E. E. Hoadley, M.I.E.E., engineer and manager of the Corporation Electricity Supply Undertaking at Maidstone, has been appointed honorary secretary of the Electric Vehicle Committee, in succession to Mr. F. Ayton, M.I.E.E.—The Millns Electrical Company, 17, Whitefriars-street, London, E.C. 4, inform us that they have been appointed sole selling agents for Great Britain and the Colonies for the products of Messrs. G. Meidinger and Co., of Basle, Switzerland. These products include electric motors of all types up to about 300 h.p., electric generators, blowers for all purposes, turbo compressors, transformers, starting and control gear, &c.

THE LATE MR. A. S. HILL.—We regret to have to record the death of Mr. A. S. Hill, late chairman and managing director of "The Coventry" Chain Company, Limited, Coventry, which occurred on the 31st ultimo. Mr. Hill was a native of Coventry and was educated at Allesley Hill and at Bath College. He was first employed by the Coventry Machinists' Company, Cheylesmore (now Messrs. Swift of Coventry, Limited), and was afterwards appointed manager of the firm's branch in Boston, U.S.A. After several years this branch was discontinued and, returning to England, Mr. Hill started manufacturing chains on his own account. His first production was a 1-in. pitch block chain which was put on the market in 1896, and since that time the business has developed to an extent which is familiar to most of our readers. In normal times some 2,000 hands are employed by the company. Mr. Hill took an important part in the public life of his native city and occupied the office of Mayor for two particularly strenuous years during the war. He was only 54 at the time of his death and leaves a widow, two sons and a daughter.

SAFETY BOLT FOR ELECTRICAL MINING APPARATUS.

In electrical switch gear, and other apparatus, for use in fiery mines, it is necessary to prevent the flame from an explosion inside the apparatus from igniting the gas in the mine. Usually it is practically impossible to make the casing of the apparatus strong enough to withstand an internal explosion without fracturing unless some device in the nature of a safety valve be fitted in order to relieve the pressure. Generally speaking, however, such devices have the drawback that, if made of sufficient area to relieve the pressure effectively, they are liable to permit the passage of flame which would ignite the external gas—possibly with disastrous results.

To avoid the difficulties above referred to, the Electrical Apparatus Company, Limited, Vauxhall Works, South Lambeth-road, S.W. 8, have recently put upon the market a device which enables the cover of the apparatus itself to act as a safety valve. It will be obvious that a very slight lift of the comparatively large cover of the apparatus will provide an opening of sufficient area to relieve the pressure, and at the same time the passage of the gases through the narrow space between the flanges will cool them sufficiently to prevent the access of flame to the air in the mine.

The device consists of an ordinary bolt on the shank of which is fitted a brass cup and cover slightly larger in diameter than the head of the bolt; in the case of a $\frac{1}{2}$-in. bolt, the cup is $1\frac{1}{2}$ in. in diameter externally and $\frac{1}{2}$ in. long. Inside the cup is a helical steel spring, the strength of which is such that a considerable pressure is required to force the cover into the mouth of the cup. The bolts, with the spring cups, are used in place of ordinary bolts to hold the cover of the switch or other apparatus in position, and are tightened up so that the top of the spring cup cover is just flush with the upper edge of the cup. In this condition, a small circular space, about $\frac{1}{32}$ in. in depth, is left between a flange formed on the edge of the cup cover and the bottom of a recess formed in the side of the cup. It is thus still possible for the cup and with it, of course, the cover of the apparatus, to lift for the above-mentioned distance against the action of the spring, but further movement is prevented by the flange of the cup cover coming into contact with the bottom of the recess. In this way the internal pressure is relieved, but the exit for the gases cannot exceed $\frac{1}{32}$ in. in width, and this, with the broad, machined flanges usually employed, will cool the gases sufficiently to prevent the passage of flame. It should, perhaps, be pointed out that the function of the spring is not to resist the pressure of the explosion, but merely to press back the cover after an explosion has occurred. The force of the explosion is taken by the bearing of the cup cover on the bottom of the recess in the cup.

The bolts, at present, are made in the $\frac{3}{8}$-in., $\frac{1}{2}$-in. and $\frac{5}{8}$-in. sizes, for use either as set screws or with nuts, and the pressure required to lift these are $1\frac{1}{2}$ cwt., 2 cwt. and $3\frac{1}{2}$ cwt., respectively, per bolt. As supplied, the parts are kept together, with the spring in compression, by a ring let into a groove turned in the shank of the bolt, and they are used without being taken to pieces in exactly the same way that ordinary bolts or set screws would be employed. They have been tested by filling a box with explosive mixture and placing it in a chamber containing a gas mixtue of a very inflammable character. The mixture in the box was afterwards exploded by means of an electric spark without damaging the box or igniting the gas in the chamber. It is, perhaps, hardly necessary to add in conclusion, that although these relief bolts have been specially designed for the purpose explained above they may be found useful for other applications in engineering and electrical work.

CHINESE TRADE WITH ITALY.—The Chinese Consul at Trieste has made arrangements with the Italian Government to hold a Chinese Manufacturers Exhibition at Trieste, in order to promote the trade relations between the two countries. After a conference between the Ministries of Foreign Affairs, and Agriculture and Commerce, the proposal has been approved.

REPRESENTATION OF UNITED KINGDOM FIRMS IN ITALY.—In view of the difficulty of dealing adequately with calls for tenders by public bodies in Italy, when the tendering firm is of foreign origin, the question of establishing a native house for the purpose has recently been considered by the Commercial Counsellor to His Majesty's Embassy at Rome. In the opinion of the legal adviser to the Embassy, United Kingdom contracting firms might find it advantageous to consider the question of establishing branch houses ("filiali") in Italy, the directors of which can be either British or Italian. British firms who may wish to adopt the course suggested can obtain particulars as to the formalities necessary for registration and as to the taxation to which they would become liable, on application to the Department of Overseas Trade, reference being made to D.O.T. 536/6/F.G.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—When full allowance is made for speculative variations, the contraction of trade is forcefully reflected in the Sheffield bankers' clearing-house returns for Saturday last, which stood at 1,145,014*l.*, as compared with 3,045,134*l.* for the corresponding week of last year. The best that can be said of the current position is that a serious endeavour is being made on all hands to face economic facts, and that prices are gradually approaching a more attractive level. As the margin between local quotations and those of foreign competitors decreases, inquiries become correspondingly more numerous. To-day, though the amount of new business actually booked by engineering concerns is small, buyers appear to be taking a keener interest in the principal lines of manufacture. Some of the biggest makers of engineering plant are engaged at full pressure on orders for the Colonies. Output is also maintained at a fair level by makers of railway rolling-stock. Busy conditions, however, are almost solely confined to those firms which entirely suspended operations during the coal strike. The current spurt is therefore largely of an artificial character, and affords no reliable indication to the real trend of affairs. As a matter of fact, the position of some of the oldest established concerns of steel-makers and engineers is actually worse than a month ago. Hire rolling-mills have difficulty in finding three days' work a fortnight, particularly where shovel-plate production is concerned. The state of the crucible trade has not improved. On top of the anxiety arising from the American tariff proposals is the knowledge of a marked expansion in Continental production of this class of material, chiefly in Germany and France. Exceptional instances of activity are to be found, but as a general rule tool-makers have barely sufficient orders to keep plant running. Steel makers are speculating on the likely effect of pig-iron shortage when trade improves. Stocks at furnaces have mostly been absorbed, and as current production in the Derbyshire and Lincolnshire districts is exceptionally low, a serious dearth of supplies may result, unless coke producers can be induced to institute a further substantial cut. The future price of Crown bars, now offered at 16*l.*, will be under consideration at a meeting of the South Yorkshire Bar Iron Association, to be held on Monday.

South Yorkshire Coal Trade.—Less buying and increased uncertainty as to prices are the principal features of the market. Except where special sales are effected, collieries are adhering to former rates. Further congestion at sidings is prevented by the restriction of output. Merchants confidently forecast an early rush of orders for house coal, in which case the price movement is expected to be upwards. How this will affect manufacturing fuel is uncertain. Deliveries at steel and engineering works are still of a hand-to-mouth character, but values on the whole are firm. Coal owners do not appear disposed to meet manufacturers on the question of contract rates. Failure to find an outlet for smalls is the crux of the whole position. Much depends on the trend of events in regard to the Lancashire cotton industry. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 37*s.* to 38*s.*; Derbyshire house coal, 35*s.* to 37*s.*; Derbyshire best large nuts, 34*s.* to 35*s.*; Derbyshire small nuts, 33*s.* to 34*s.*; Yorkshire hards, 34*s.* to 35*s.*; Derbyshire hards, 33*s.* to 34*s.*; rough slacks, 19*s.* to 20*s.*; nutty slacks, 17*s.* to 18*s.*; smalls, 12*s.* to 13*s.*

STEPNEY ELECTRICITY UNDERTAKING.—In his report dealing with the year ending March 31 last, Mr. W. C. Tapper, engineer and manager of the Stepney Electricity Undertaking, states that the gross profits for the year amounted to 53,349*l.*, which is just over 7$\frac{1}{2}$ per cent. on the averaged capital expenditure and 10$\frac{1}{2}$ per cent. on the balance of the outstanding loans. After meeting loan interest, repayment, &c., the net profit amounted to 9,376*l.* Increase in cost is shown in practically every item of the revenue account and the cost per unit for coal and wages was 185 per cent. above that for 1913–14. A slight drop in units sold, due entirely to lower power demand, was recorded during the year, but the total sales were still considerably higher than for any other municipal undertaking in the county of London. No less than 502 house service connections were made during the year. This is the largest number made in any one year in the history of the undertaking.

BRITISH AND GERMAN COMPETITION.—Messrs. William Johnson and Sons (Leeds), Limited, have received a contract for the supply of a complete plant of machinery for the manufacture of retorts, condensers, &c., in connection with a new spelter works which is being installed by a Continental firm in Indo-China. The plant consists of grinding, screening, measuring, mixing and pugging machinery for the various kinds of refractory clays, chamotte, &c., also hydraulic press with pump, accumulator and accessories for the production of the retorts. There was keen competition on the part of German firms who have been anxious to retain such work in their own hands, Messrs. Johnson being the only British firm who are in a position to handle the contract. During the war the Leeds firm were called upon to equip several new spelter works in this country and the Continental firm in question made careful inquiries as to the working of those plants, with the result that they placed the order with the British firm. We illustrated Messrs. Johnson's spelter works plant on February 15 and 22, 1918 (vol. cv., pages 167 and 200.).

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Whilst it is fully recognised that until cost of production is still further lowered, general resumption of operations at the blast furnaces cannot be looked for, it is gratifying to hear of some idle plant being again re-started, and it is pleasing to learn that before long probably 25 per cent. of the furnaces built in this district will be blowing once more. The number at work has been added to this week by the lighting up of a furnace at Newport, and a second may shortly be running at those works, whilst the Lockerby Ironworks Company are preparing to restart. Scarcity of No. 3 Cleveland pig-iron is still pronounced, and what parcels are offered are readily bought at 135*s.* The lower qualities are plentiful. Foundry 4 is on sale at 125*s.*, and No. 4 forge and mottled are being pressed on the market at 117*s.* 6*d.*, whilst makers experience much difficulty in disposing of white iron at 115*s.* The foregoing quotations are for home consumption. There is now practically no foreign inquiry for Cleveland pig-iron.

Hematite.—Last week's 20*s.* cut in hematite prices appears to have stimulated, to some extent, home demand, but with more furnaces blowing, supply is very ample. Nos. 1, 2 and 3 East Coast brands are 140*s.*, and No. 1 is 142*s.* 6*d.* Whilst these are the recognised market quotations both for home consumption and for shipment to foreign destinations, producers have a free hand as regards export trade, and doubtless they would not hesitate to accept orders from abroad at a little below the foregoing figures.

Industrial Paradox.—In a return issued by the Tees Conservancy Commissioners of iron and steel imported to the Tees from Holland, Belgium, France, Norway and Germany for the ten months ending August 31 last, as compared with the corresponding periods of 1912–13 and 1913–14, it is shown that the tonnage of pig-iron for the latter years amounted to 1,073 tons and 312 tons respectively, compared with 37,463 tons in the current year.

Manufactured Iron and Steel.—New business in finished iron and steel is within narrow limits, but some little improvement is noticeable. With expansion of operations at the various works slow, it is gratifying to learn of preparations by the Skinningrove Company to re-start some of their plant. Among the principal market quotations are common iron bars, 16*l.*; marked bars, 20*l.*; steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 11*l.*; steel boiler plates, 19*l.*; steel ship, bridge and tank plates, 14*l.*; steel angles and joists, 13*l.* 10*s.*; tees, 14*l.* 10*s.*; rounds and squares, 13*l.*; flats, 14*l.*; heavy steel rails, 14*l.*; fish plates and sleepers, 19*l.*; black sheets, 17*l.*; corrugated galvanised sheets, 20*l.* 10*s.*

Iron and Steel Shipments.—August shipments of iron and steel from the port of Middlesbrough are officially given at 28,213 tons, comprising 6,116 tons of pig-iron, 1,560 tons of manufactured iron, and 20,537 tons of steel. Of the pig-iron despatched 1,381 tons went foreign and 4,735 tons coastwise; of the manufactured iron loaded, 1,370 tons went foreign and 190 tons coastwise; and of the steel shipped, 17,955 tons went foreign and 2,582 tons coastwise. Wales was the heaviest receiver of pig-iron, taking 2,680 tons, whilst Scotland was second with 1,375 tons. Once more India was the largest customer for both manufactured iron and steel, importing 1,045 tons of the former and 3,536 tons of the latter. Among other importers of steel were: Australia, 2,954 tons; New Zealand, 2,482 tons; West Africa, 2,318 tons; Natal, 2,259 tons; Cape Colony, 1,212 tons; and Uruguay, 1,174 tons.

Foreign Ore.—There is absolutely nothing doing in foreign ore. Consumers have heavy stocks and large deliveries to take against old contracts.

Coke.—Coke shows a downward tendency, but is still too high to meet views of local consumers. Sellers ask 35*s.* for Durham blast-furnace kind delivered, whereas users consider the maximum quotation should be 30*s.*

STATISTICS OF TIN.—From figures issued by Messrs. Ricard and Freiwald, 120, Fenchurch-street, E.C., we learn that the stocks of tin in London and other ports of the United Kingdom on the 31st ultimo amounted to 5,755 tons, as compared with 6,124 tons at the end of the previous month and with 4,531 tons in stock at the end of August, 1920. A further quantity of 635 tons was landing or is in transit to the United Kingdom on August 31 last, and the quantity afloat from the Straits and Australia at the same time was 1,065 tons and 100 tons, respectively. The total supply for the United Kingdom was therefore 7,555 tons, whereas the corresponding figure for July 31 last was 7,984 tons and that for August 31, 1920, was 6,651 tons.

THE ITALIAN CUSTOMS TARIFF.—His Majesty's Consul-General at Milan (Mr. W. A. Churchill) points out that the new Italian customs tariff, which came into force on July 1, does not appear to be generally known or understood by United Kingdom firms. The effect of the high exchange and the high customs tariff has been to bring imports into Italy from this country, in common with others, to a standstill. Exporters to Italy should therefore make careful inquiries as to duties, and other points, before shipping. The complete new customs tariff appeared in *The Board of Trade Journal* of July 21, and intimation will also be given there as to any reductions in duty which may be made. The Department of Overseas Trade, 35, Old Queen-street, Westminster, S.W. 1, is also prepared to render assistance to inquirers in respect of these matters.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A better tone prevails in the steel trade of Scotland, but that unfortunately is about as far as the improvement has reached and conditions in the steel works are not appreciably altered. Quite a number of orders have been fixed up, but these, on the whole, do not amount to a very heavy tonnage and could easily be wiped off quickly if more plant were put into operation. Few important contracts have been given out, but inquiries are much better, and there is a strong feeling that before long the various works will be much busier. With the shipbuilding industry such an outstanding factor in connection with the steel trade, a big improvement there is a necessity, but there are no signs yet that shipowners contemplate ordering new vessels. The costs are still against such a procedure, and although these have eased considerably they must fall much further. Low-priced steel material is coming into this market fairly freely from the Continent, but in the case of that of German origin the date of delivery—about three months ahead—is not satisfying home consumers, and this may help the local producers. The black sheet makers are rather badly off for work, and prices were recently reduced 1*l.* per ton to encourage business, but only a modified number of new orders have been forthcoming. Some good inquiries are in the market, and there are high hopes of securing a fair proportion of these.

Malleable Iron Trade.—The West of Scotland malleable iron trade shows little change, and a reduced number of shifts is all too general. Makers are finding fresh business very difficult to pick up, and the outlook is not too bright. Here, again, the competition from the Continent is being felt, and although the prices are much under those of the local makers they are stiffening-up because of the amount of work on hand, which will keep them busy for some time ahead. The home producers have made no change in prices, and "crown" bars are still called 16*l.* per ton.

Scottish Pig-Iron Trade.—A slightly better feeling is noticeable in the pig-iron trade of Scotland, but business is very slow in opening out. Dealings are confined to small lots and the output from the furnaces now in blast is not very large. There are prospects of fuel becoming cheaper in the near future, and with oncost charges also easing, the prices for Scottish pigs will accordingly be reduced further and trade will probably expand. The number of furnaces now in operation is still four.

THE INSTITUTION OF GAS ENGINEERS.—The annual meeting of the Institution of Gas Engineers, which was postponed from last May, in consequence of the industrial unrest then prevalent, is to be held, under the presidency of Mr. Thomas Goulden, M.Inst.C.E., chief engineer of the Gas Light and Coke Company, on October 11 and 12, at the Central Hall, Westminster. On the following day, H.M. Fuel Research Station at East Greenwich is to be visited, by permission of the director, Sir George Beilby, F.R.S., Hon.Mem.Inst.GasEng. Members of the French Gas Society who were invited to take part in the proceedings, regret that they are obliged to postpone their visit till next year.

UTRECHT FAIR BULLETIN.—We have received from the Federation of British Industries a copy of the Utrecht Fair edition of the Bulletin of that federation intended to be circulated amongst buyers at the Utrecht Fair (September 6 to 16) and also in the important market of the Dutch East Indies. This publication, which is printed in Dutch and English, contains articles on shallow-draught steamers, engineering production and repair work, British engineering in peace and war, British implements for tropical cultivation, artificial fertilisers, narrow-gauge railways, and other matters calculated to stimulate interest in British manufactures amongst Dutch buyers. The address of the Federation is 39, St. James'-street, London, S.W. 1.

NEW SOUTH WALES BRIDGE CONSTRUCTION CONTRACTS.—We are officially notified that the Department of Public Works, Sydney, New South Wales, invite tenders for the manufacture, supply and delivery of: (1) Three steel truss spans for a bridge over River Murray at Mulwala; (2) Construction of bascule bridge, with timber side spans, over Murrumbidgee River at Carrathool. Tenders will be received by the Department of Public Works, Sydney, New South Wales, up to Monday, October 10, in the case of No. 1, and up to Monday, September 19, in the case of No. 2. A set of the relative specifications, conditions and tender form forwarded by His Majesty's Trade Commissioner at Sydney can be inspected by United Kingdom firms interested, on application to Room 59, Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1.

A FLOATING EXHIBITION.—According to present plans a specially-designed exhibition ship, to be called the "British Industry," will set out from the Thames in the summer of 1923 to visit the chief ports of the world in order to bring British goods to the notice of overseas buyers. The ship, with its motor engines and fittings, will itself form an exhibit of British products, but in addition to this four of the eight decks will be devoted to the exhibition proper. This will include a reception hall, offices, inquiry bureau, bank, &c., as well as a kinematograph theatre in which manufacturing processes can be illustrated. The promotors of the scheme are The British Trade Ship, Limited, 12, Grosvenor Gardens, London, S.W. 1, whence all particulars can be obtained, but we understand that information is also obtainable at the exhibition now open at Olympia.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Generally the coal market shows no change. Supplies in most cases are excessive, and prices are irregular and dependent on individual circumstances. The steadiest section is best and second-class Admiralty large, which is round 32*s.* 6*d.*, and best steam smalls at 19*s.* to 19*s.* 6*d.* These, however, are "patchy," and buyers able to take prompt delivery can in places obtain concessions. The demand for other grades of both large and small is comparatively small, and buyers evidently are of the opinion that by waiting they will secure their requirements at yet lower levels. Best Monmouthshire large was freely offered, and prices ranged from 27*s.* 6*d.* to 30*s.*, while dry large was in poor demand with the best descriptions worth no more than 31*s.* and inferiors down to 25*s.* Washed nuts were from 30*s.* to 35*s.*, with washed small from 16*s.* 6*d.* to 18*s.* 6*d.* In the bituminous section, No. 2 Rhondda throughs ranged from 20*s.* to 23*s.* The difficulties of colliery owners to keep their pits working has been aggravated by the refusal of the railway companies to run wagons on to the dock until boats are in position to load, in consequence of congestion at the docks. Thousands of tons of coal are standing at the docks and in sidings, owing to the lack of demand and the inability of the tipping facilities to deal with the quantities arriving for shipment in the restricted working hours. Foreign cargo exports from South Wales in the past month totalled 565 cargoes of 1,395,429 tons, the highest total reached this year, comparing with 924,434 tons in January and 952,442 tons in March. Last month's total was, however, considerably less than the quantity despatched in August, 1913, when shipments reached 2,099,219 tons, while the total of 4,751,359 tons for the eight months ended August of this year compared with 19,542,464 tons in the corresponding period of 1913. It is reported that the French State Railways have provisionally contracted for 20,000 tons of best Monmouthshire large coal delivery over two months after the final placing of the contract. Two-thirds is to be delivered at the North French ports and one-third at the Bay ports. The lowest tender was 82·99 francs c.i.f., equal to 35*s.* at the current rate of exchange. This price has been sent to the original tenderers, who are free to underout the lowest tender. No tender less than 10 per cent. below the above price will be considered. Should anyone be willing to supply at 10 per cent. or more below the 82·99 francs, then the original lowest tenderer and the subsequent tenderers would be free again to quote for the business. How the company which has provisionally taken the business can hope to make a profit is regarded as a mystery, for the current price of best Monmouthshire large is round 29*s.*, with the freight to Rouen from 7*s.* to 9*s.*, according to size.

Iron and Steel.—As Continental prices are gradually being raised and approximating prices here, the prospects of the Welsh tin-plate trade are regarded as brighter. Belgian and French billets have been increased to 6*l.* 15*s.* per ton f.o.b., while Belgian bars are at the same figure and French bars 10*s.* less. Welsh sheet and tin bars are 9*l.* 10*s.* German steel works are reported to be full up till the end of December, and for this reason it is expected that a revival will take place for Welsh tin-plates. Meanwhile prices are rather easier on the basis of 23*s.* per box for prompt business and 22*s.* for forward delivery.

S.S. "CAIRNROSS."—An addition has just been made to the Thomson Line service between Canada and the North-East Coast of the Cairn Line of Steamships, Limited, in the s.s. Cairnross, which has completed her trial run at an average speed of over 13 knots, on a draught of 20 ft. 6 in. The vessel has a deadweight capacity of 8,710 tons on a draught of 25 ft. 6½ in. She is 425 ft. between perpendiculars. The bulkheads in the holds and deep tanks are on the Hogg-Carr system. Electrically-driven fans are provided for ventilating the holds, in addition to cowls. The ship is fitted with double reduction geared reaction turbines by the Parsons' Marine Steam Turbine Company, Limited, the power being 3,100 shaft horse-power. The three single-ended boilers can be fired by coal or oil on White's low-pressure mechanical system. When oil fuel is employed it is carried in a deep tank aft of the machinery space, and not in the double bottom.

STRENGTH OF REFRACTORIES AT HIGH TEMPERATURES.—The arrangement for testing refractory materials within a furnace at high temperatures which E. Rengade and E. Desvignes described a few weeks ago in a paper presented to the Paris Académie (*Comptes Rendus*, vol. 119, pages 134 to 137) is that of a machine for determining a Brinell hardness. Instead of the ball of Brinell, however, they use a cone of an angle of 90 deg., as introduced by Ludwick. The furnace is of the Rosenhain graphite ring type. The specimen is roughly made of cylindrical shape, about 30 mm. in diameter; the shape does not matter provided the top and bottom are plane. On the top rests the cone; it is mounted in a graphite ring so attached to a jointed rod that the rod can be withdrawn to take pyrometer observations, and can afterwards be lowered on to the specimen and loaded with a weight of 10 kg. This is done when the temperature inside the furnace has become constant; the load is then put on for about 10 minutes, after which the temperature is redetermined. The curves obtained with different materials, high or low in silica or alumina, are regular and much of the same type showing that a gradual softening sets in, at temperatures which in the cases mentioned ranged from 1,150 deg. up to 1,270 deg. C., and which increased as the temperature was raised to 1,500 deg. C. maximum.

TURBINE DOUBLE-REDUCTION GEAR OF THREE-CASE TYPE FOR STEAMSHIPS.

CONSTRUCTED BY SCOTTS SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GREENOCK.

(*For Description, see Page* 376.)

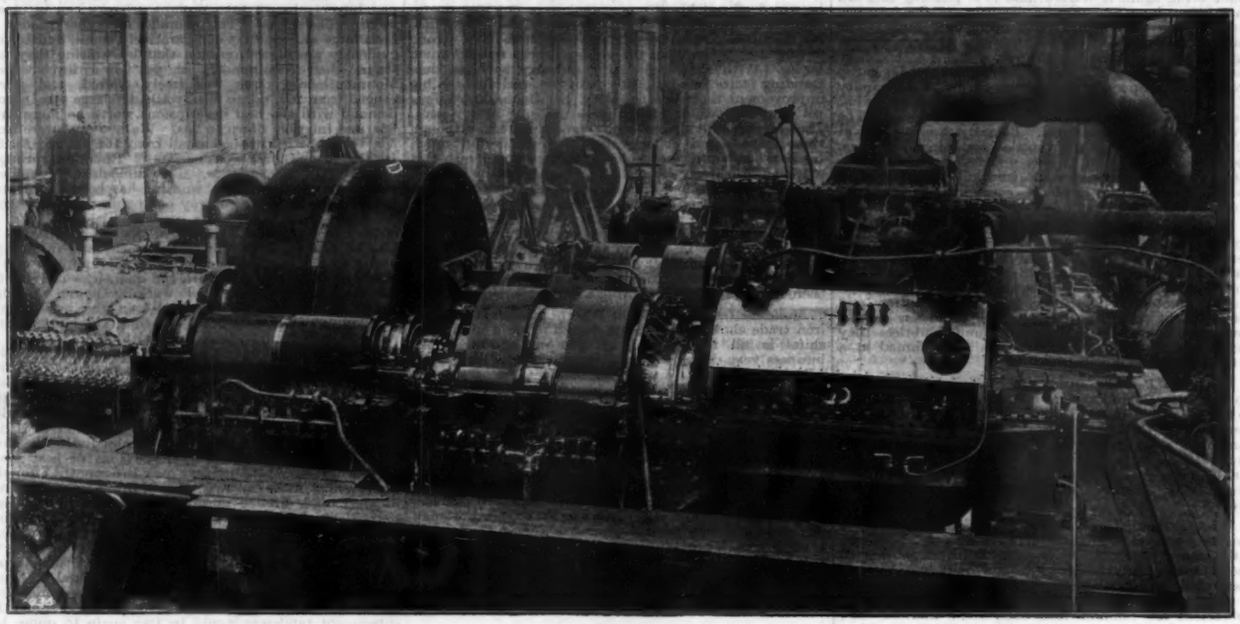


FIG. 1. VIEW WITH GEAR COVERS REMOVED.

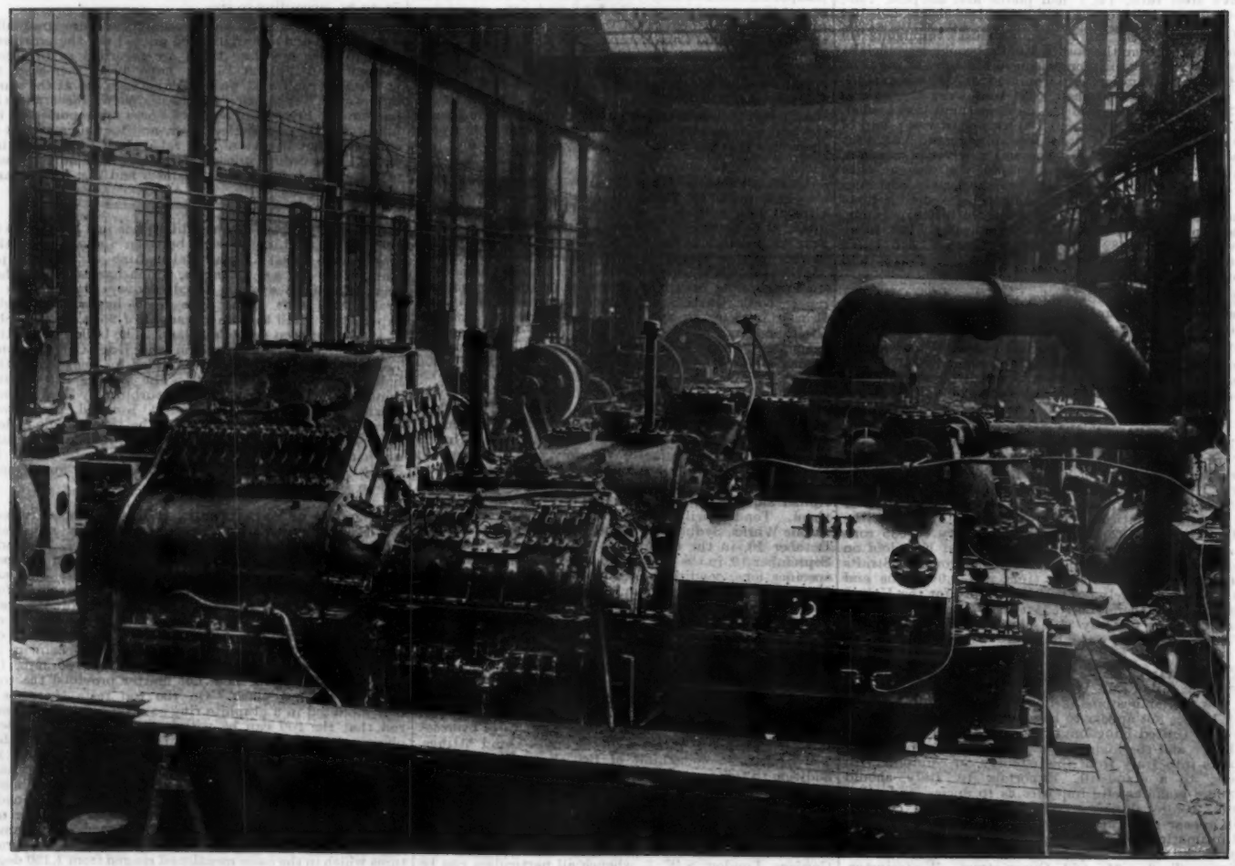
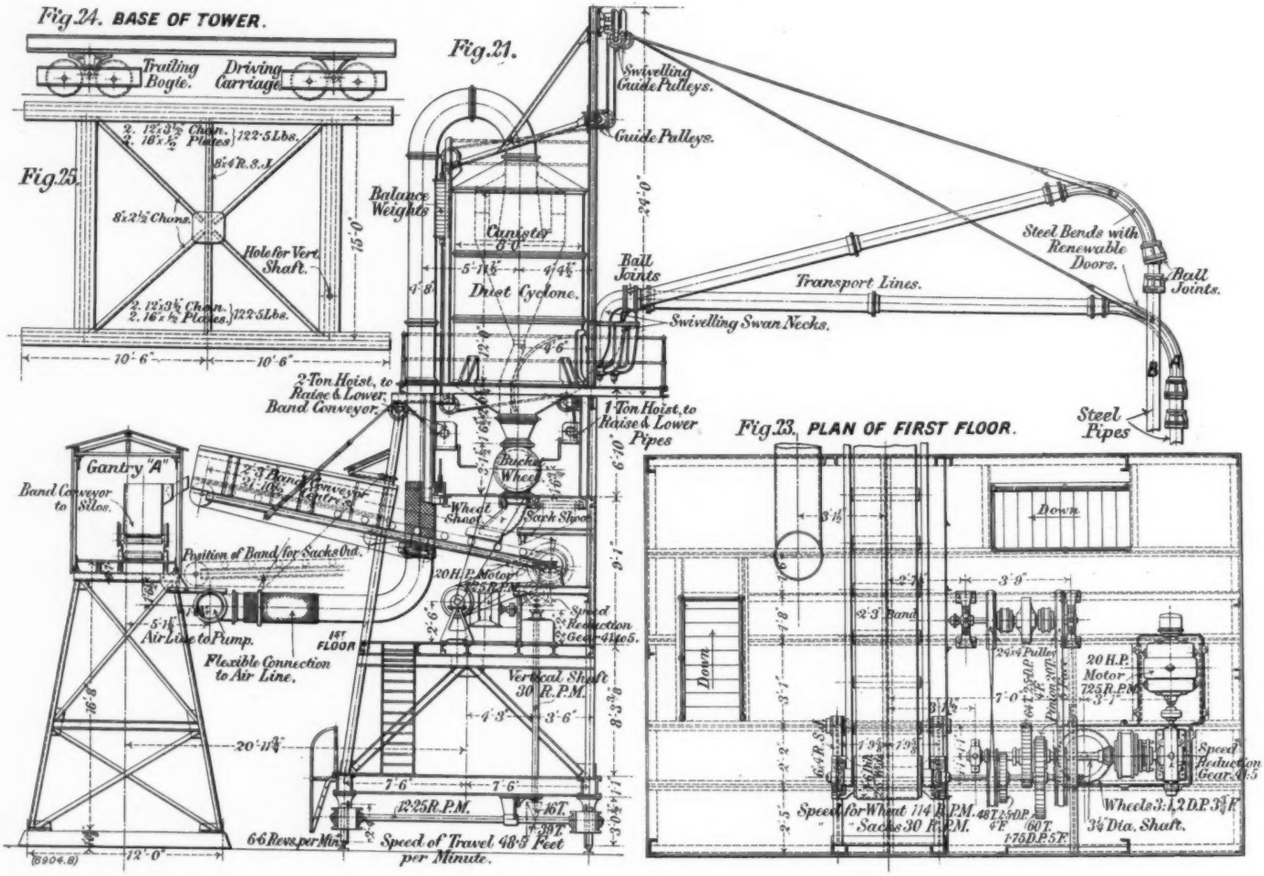


FIG. 2. VIEW WITH COVERS IN PLACE.

PNEUMATIC GRAIN-DISCHARGING PLANT FOR THE U[NION]

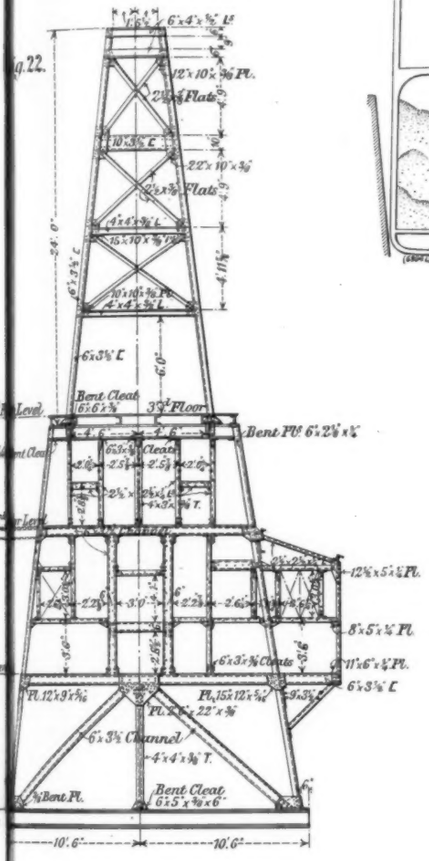
(For Descrip[tion] see Page



UNION COMMERCIALE DE BORDEAUX-BASSENS, FRANCE.

(Description Page 370.)

Fig. 22.



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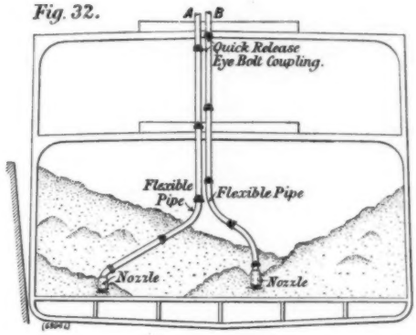
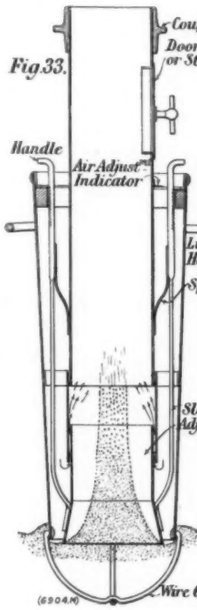


Fig. 33.



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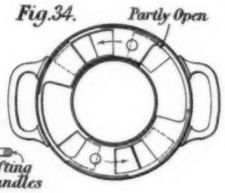

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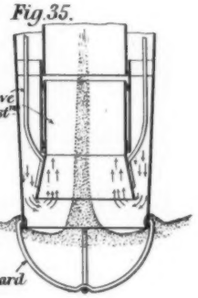

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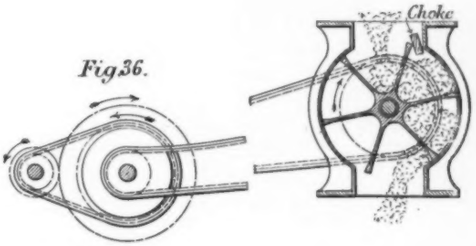

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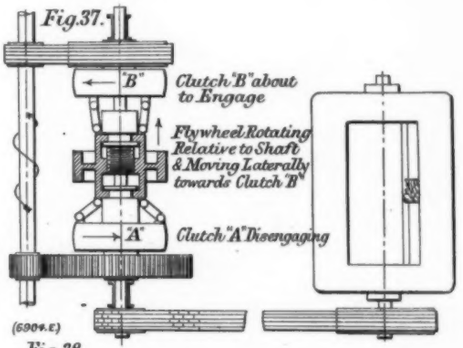
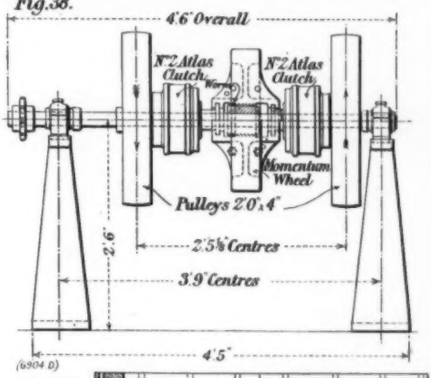

"B"
Clutch "B" about to Engage
Flywheel Rotating Relative to Shaft & Moving Laterally towards Clutch "B"
"A"
Clutch "A" Disengaging

Fig. 38.



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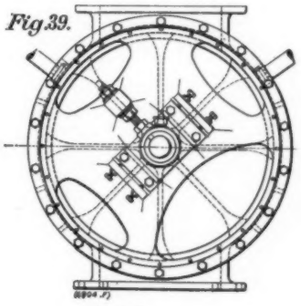

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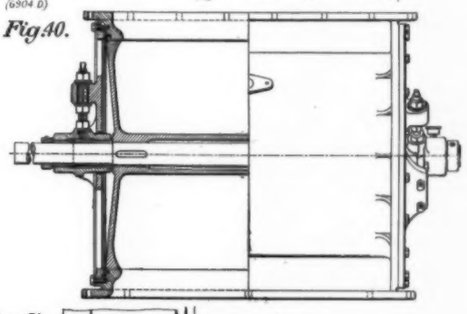

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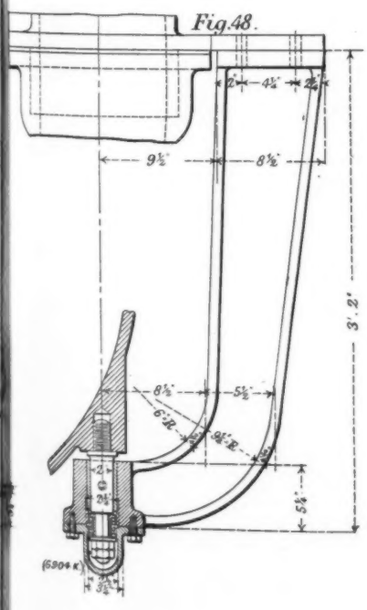
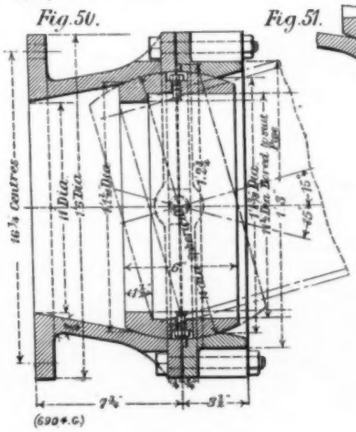


Fig. 49.

Fig. 50.



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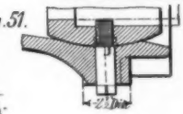
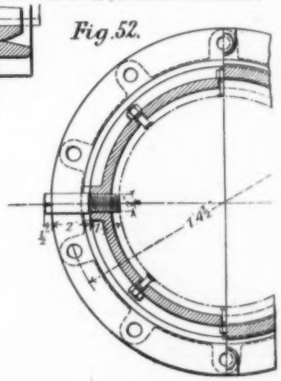


Fig. 52.



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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the PNEUMATIC GRAIN-DISCHARGING PLANT FOR THE UNION COMMERCIALE BORDEAUX-BASSENS, FRANCE.

ENGINEERING.

FRIDAY, SEPTEMBER 9, 1921.

TRADE UNIONISTS AND CAPITALISM.

READERS of Kingsley's "Hypatia" will remember that when the hero was sent by St. Cyril to confront the philosopher he was instructed to confine himself to denunciation and not to attempt to argue with her. This method of controversy has ever been a popular one, and is exemplified afresh in the presidential address delivered to the Trades Union Congress by Mr. E. L. Poulton. "Man never is but always to be blest" has held throughout every age and throughout every civilisation. Life consisting as it does of a continuous adjustment of the organism to the environment, is never in complete accord with its surroundings, and the pessimistic observer can accordingly always find more than a sufficiency of ills on which to base his diatribes against current conditions. The philosopher, however, is less concerned with the actual existence of evils, than with the question as to whether they are increasing or diminishing. The absolute in fact is of less importance than the relative, and he will judge the merits of any particular social system by a comparison with other types of society.

In his address, Mr. E. L. Poulton said "We cannot, and will not, be parties to the continuance of methods and a state of society that produces the present appalling results on vast multitudes of people." Mr. Poulton cannot consistently attribute the present prevalence of unemployment to what he would, no doubt, call capitalism, for as he well knows the conditions are far more appalling in Russia, where capitalism has been destroyed, than they are here. Moreover, the records of the past show that famine and unemployment were much more common before the present industrial system was inaugurated than they are to-day, and we are strongly of the opinion that could an impartial jury of archangels be empanelled, the blame for no small proportion of the present distress in this country would be laid upon the shoulders of organised labour, whose leaders have in general followed the methods of the mediæval school men and their intellectual successors the Fabian Society, and prefer to discuss social and economic questions on the basis of *a priori* assumptions, rather than by the methods of science.

A resort to the latter shows the results of capitalism to be anything but appalling. Historians tell us that not many generations since, this country was never far removed from the danger of famine, and famines were, in fact, of frequent recurrence until the rise of capitalism. Moreover, means of transport were so defective that occasions occurred in which there was a surplus of food in one county, whilst in another only a few score of miles distant people were dying from starvation.

Now, thanks to capitalism, not only is our country intersected with a marvellous network of railways and canals, but even under war conditions, the ships of the capitalist brought meat 8,000 miles to 12,000 miles across the ocean and delivered it into store here at a total cost for transport, refrigeration and storage of less than 1*d.* per pound. To-day, as one result of capitalism, we not only support a population 2½ times as great as one hundred years ago, but the workman is able to earn enough in a 48-hour week to maintain him not merely in a better position than his great grandfather was able to attain with a working week of 72 hours, but finds himself in possession of comforts undreamed of even by the wealthy of one hundred years ago. Tea at that date was a luxury; now, as one result of the capitalistic development so strenuously denounced, it is commonly regarded as a necessity. The water supply of one hundred years ago was inconvenient and highly dangerous. Thanks to capitalism means were found of rendering the contaminated waters of the Thames equal from the hygienic standpoint to the nominally unpolluted waters of Loch Katrine. Even the merely "idle rich" have played no small part in bringing about an amelioration of the amenities of life as lived by the "common people." One hundred years ago gas cost 14*s.* or more per 1,000, and was developed as a rich man's light, and could hardly have been developed in any other way. As the necessary experience was gained thanks to the operations of capitalism the price was reduced, so that gas became available to all classes of society. The history of electric light and power distribution was in many respects similar. At first the electric light was necessarily a rich man's light, but in this instance the development was hindered by a desire to dispense with capitalism. The end was not attained. British capitalists no doubt were deterred from financing the necessary pioneering work, but the task was merely transferred to foreign capitalists who ultimately supplied us with equipment and machinery which in the normal course of things would have been developed here. According to an official report this attempt to dispense with the aid of the capitalist has resulted in a loss to the country in wages and in delayed development equivalent to at least 100,000,000*l.* per annum.

Lord Haldane has recently pointed out that the doctrine of relativity has far wider implications than are dealt with in Einstein's theory. In social and economic matters we can have in the very nature of things no absolute standard to serve as a basis of comparison. The only test we can apply as to whether society is or is not developing on the right lines is not by a comparison with a Utopia conceived by labour leaders and others, who confess "that science leaves them cold," but by comparisons with the past or with other societies existing to-day under a different *regime*. Under any such test as this, capitalism emerges triumphant. Socialism, on the other hand, has been tried on a small scale by communities of ardent devotees and has yet invariably failed. It has now been tried on a gigantic scale in Russia, and the result has differed from preceding essays merely in that the failure has been correspondingly gigantic. In some sort co-operative societies constitute an experiment in socialism, and their history is hardly encouraging. There is, in short, no record of these societies creating any new industry, or effecting any really notable improvement in any previously existing industry.

The reason for this lies in the circumstance that mind is the main factor in the creation of wealth and uses capital and labour as its tools. It is accordingly the genius of the individual that counts, and a genius cannot work in leading strings. Carnegie, for example, could never have built up the American steel industry as he did to the immense benefit of the "common people," had he not been a free agent in absolute control of his undertakings. Indeed it is on record that owing to differences of opinion, he had to get rid in turn of each of his original partners, and had he had to justify his daring enterprises to a committee of workmen the steel industry of America might still be in its infancy. His profits, large as they were, were only a fraction of those simultaneously received by his workmen; but instead of being expended mainly in personal indulgencies of one kind or another they were spent in improving equipment and in extending the works and thus providing well-paid employment for many more men. Mr. Henry Ford is also, we understand, very much of an autocrat in the conduct of his works, and it is only when an autocrat of genius engages in industrial undertakings that new creations of wealth on any large scale are effected.

In his address, Mr. Poulton attempted to draw a parallel between the "ca' canny" methods prevalent in certain trades and the occasional practice of firms in restricting production when the market is overstocked. Even a labour leader ought, however, to be capable of perceiving a vast distinction between the two cases. In the first place the workman breaks his contract of service when he deliberately refuses to do a fair day's work. No such contract is violated when a manufacturer, finding a glut in the market, reduces his output. The real parallel in this case is with a strike. The workman having his labour to sell refuses to work save at what he considers a fair price, and the manufacturer having goods to sell refuses to make them unless he can get what he considers a fair price. In particular instances, the workman may be greedy and unreasonable in striking, and in particular instances the manufacturer may be grasping and

unreasonable in stopping production, but neither a strike nor a stoppage is necessarily wrong *per se*, whilst a "ca canny" policy always is. It is sometimes said that there can be no over-production of goods so long as there are people unsupplied. On this basis it would be impossible to produce too many diamond rings, or Rolls-Royce motor cars. In fact, however, even food may be over-produced, as happens at times when exceptional catches of fish are made.

In another part of his speech Mr. Poulton advocated a further reduction of working hours. So far as such a reduction would add to the opportunities of the mass of the people, the aspiration will have the sympathy of many of us, tempered, however, by the consideration that the reduction must not diminish output or increase working costs. The growth of inventions may no doubt some day make it possible to do this, but the time is certainly not yet. As a remedy for unemployment, however, the reduction of working hours is a failure save as a temporary expedient for avoiding the discharge of workmen. The late miners' strike, constituted in effect an enormous diminution of working hours, but the result was a large increase in the number of those for whom no work could be found.

THE SPONTANEOUS COMBUSTION OF COAL IN MINES.

THE frequency with which fires arose spontaneously in certain coal mines, led, in 1913, to the appointment of a Departmental Committee to investigate the matter, and to advise as to what were the best measures to be taken to reduce the risks. Owing, however, to the war with Germany, the work of the Committee had to be interrupted, many of the members originally appointed having to turn their energies in other directions, and only now has it been possible to issue their final Report.* From the historical review included in the report it appears that the trouble is one of very long standing. As far back as 1686, Dr. Plott, Professor of Chemistry at Oxford University, discussed the spontaneous fires in the Staffordshire coal mines, and attributed them to the presence of pyrites in the coal, a view which was subsequently endorsed by Berzelius, and remained popular for a very long period. In 1846–1850, however, De La Beche and Playfair in an official report, said that in their opinion the presence of dust was a more potent cause of spontaneous combustion than the presence of pyrites, and in 1864, Dr. John Percy came to the conclusion that pyrites played little or no part in the phenomena, and expressed views on the origin of these fires and of the measures to be taken in combating them which are in singularly close accord with those finally arrived at in the report under review. A peculiarity of the phenomenon is that it is almost unknown in the Northumberland coal area, but has always been very prevalent in Staffordshire. Outbreaks are, moreover, much more common with very thick seams, and are almost unknown in seams less than 4 ft. thick. Moreover, the greater the surface exposed to the air, the greater is the danger. Hence, coals of a porous character are more liable to fire than others, and for the same reasons falls from the roof or any other agency, which may break up the coal into fine fragments, may result in fires. For this reason, the Committee hold that it is possible that in certain cases pyrites may play some part in starting a fire, since certain varieties of this mineral disintegrate in the presence of moisture and thus break up the coal in which they are embedded. The consequent increase of surface exposed by the coal may be accompanied by a rapid absorption of oxygen, leading in certain cases to spontaneous ignition. The Committee state that coal which has been crushed in the mine by the weight above it, is more likely to take fire than coal in a compact state, and recommend accordingly that pillars shall be adequate in size, and when their removal is begun, the work should be carried on as rapidly as possible. For the same reason, inferior coal, which is commonly left behind in the vicinity of faults should be brought to bank. Timber left in the goaf, though not a primary cause of fires, may be so indirectly, as it hinders the even settlement of the roof and allows of the formation of air spaces. Neither coal nor timber should, it is stated, be used in the construction of packs. Where practicable, the long wall method of working is recommended. At large collieries, where the coal is liable to spontaneous combustion, there should be a special staff to investigate any occurrence of gob-stink or other indications of self-heating, and it is to preventive measures of this kind that the Committee look as the surest way of reducing the number of fires. In Silesia, where the coal is very liable to spontaneous ignition, very good results have followed the adoption of hydraulic stowage. A large majority of the fires originate in the wastes of worked-out seams, and this is in large measure due to the fact that there is a large leakage of air into these areas. With hydraulic stowage they can be packed so tightly as to obviate this danger. Unfortunately, the system is not universally applicable, but it has, it appears, been adopted with success in the Fifeshire coal field.

* Final report of the Departmental Committee on Spontaneous Combustion of Coal in Mines, H.M. Stationery Office. 1921. [C.M.O. 1417.] Price 1s. 6d. net.

A CONTRACT TO DO WORK FOR A LUMP SUM.

IT is very important—especially in these days of greatly varying prices and cost of labour—for those who contract to carry out work for a sum certain to realise the full extent of their legal obligations. A case recently tried by Mr. Justice Sargant affords an example of the rigorous way in which the courts will enforce a lump sum contract. The plaintiffs, who were builders, gave an estimate to effect certain specified repairs and alterations to certain property of the defendants in Charles-street. The estimate was accepted and the work was commenced. At the same time the plaintiffs were doing work on other property of the defendants in Red Lion-square. As they had reason to complain of the delay of the defendants in paying for the work in progress at Red Lion-square, they stopped the work at Charles-street and sued as on a *quantum meruit* for 264*l.* 1*s.* 10*d.*, being the alleged value of what they said they had done until the stoppage. The learned judge found that the plaintiffs could recover nothing. He followed the case of *Sumpler v. Hedges* (1898) 1 Q.B. 673, which (according to "The Law Affecting Engineers," by W. Valentine Ball) is an authority for the proposition that "Where a contract to build for a lump sum is abandoned after part execution, the builder cannot recover as upon a *quantum meruit* for the part executed." In that case after the abandonment the employer himself completed the building.

The principle is very firmly rooted, and some very striking examples of its operation are to be found in the law reports. In a case heard in 1873, a contract provided that a railway line should be completed for a fixed sum. When the railway was partially completed it was found that the proposed mode of conveying the traffic up and down a mountain was wholly inadequate. The engineer prepared new plans, and requested the contractors to construct the railway according to those plans, which they did, occasioning the excavation of earthworks greatly in excess of the quantities specified by nearly 2,000,000 cub. yards. Lord Justice James said: "What they had contracted to do for a lump sum was to make the line from terminus to terminus complete, and both these items seem to me, on the face of them, entirely included in the contract. They are not in any sense of the word extra works." It was held that the contractors could not recover the excess as an extra.

In another case a tradesman undertook to make for a lump sum certain water tanks, with certain stays, "capable of sustaining a head pressure of 60 ft. of water." Finding that, as constructed, they would not sustain that pressure, he strengthened them by adding stays, which he charged for as extra furnishings. It was held that the employer was not liable beyond the price mentioned in the contract; and that, therefore, the tradesman could not recover for the cost of putting in the extra stays (Wilson *v.* Wallace (1859), 21 Court of Sessions, Cas. second series (Dunlop), 507).

Other decisions illustrate the importance of careful surveys and investigations before the work is undertaken. Too often does the contractor rely on the measurements and estimates prepared on behalf of the other party to the contract. In one case the defendant employed an architect to prepare plans and a specification for a house, and to procure a builder to erect it for him. The architect took out the quantities; the plaintiff made a tender, which was accepted, and he entered into a contract to "execute the necessary works in erecting and completing a dwelling-house, &c., according to drawings, specifications and conditions of contract." The quantities proved to be incorrect, and the plaintiff expended upon the building a much larger amount of materials than he contemplated. It was held he could not recover the extra payment; for the employer did not guarantee the quantities (Scrivener *v.* Pask (1865), 18 C.B.N.S., 785).

An even more striking illustration of the danger of relying on other people's measurements was furnished by what is known as the "Blackfriars Bridge case." A man named Thorn contracted to build Blackfriars Bridge in accordance with plans and a specification furnished by an engineer. Part of the plans related to caissons, which turned out to be ineffective, and the work done in attempting to use them was entirely lost. The plans were then altered, and Thorn completed the bridge. The contract price and the cost of the altered work was paid, but not the cost to Thorn of attempting to use the caissons. It was held that Thorn was not entitled to recover, as for a breach of warranty that the work could be done in accordance with the specification and plans. The judgment of the court contained the following passage:—

"There can be no doubt that the plaintiff, in the exercise of common prudence, before he made his tender, ought to have informed himself of all the particulars connected with the work, and especially as to the practicability of executing every part of the work contained in the specification, according to the specified terms and conditions. It is said that it would be very inconvenient to require an intended contractor to make himself thoroughly acquainted with the specification, as it would be necessary upon each occasion for him to have an engineer by his side . . . But if the contractor ought prudently and properly to have full information of the nature of work he is preparing to undertake, and the advice of a skilled person is necessary to enable him to understand the specification, is it any reason for not employing such a person that it would add to the expense of the contractor before making his tender? It is also said that it is the usage of contractors to rely on the specification, and not to examine it particularly for themselves; if so, it is a usage of blind confidence of the most unreasonable description" (Thorn *v.* London Corporation (1876), L. App. Cas. 120).

Many other cases could be cited to show how difficult it is for a man who has undertaken to do certain work for a sum certain to get any relief. It is possible, however, to cite two cases where English judges have endeavoured to abate the extreme rigour of the law. They relate no doubt to building; but the principle is one of universal application.

In Dakin *v.* Lee (1916) 113 L.T. 905, builders undertook certain work according to specification for 264*l.* The defendant's house required structural work which included underpinning, to the front and side of the house. In a letter to the building owner, the builders had stated: "we have taken for a depth of 4 ft. of concrete below the bottom of the present brickwork." In the course of the work there were deviations from the specification: amongst other things the concrete was laid to a thickness of not more than 2 ft. In an action by the builders to recover the price of the work done by them, the Official Referee who tried the case in the first instance found that the building owner had been given something different and less strong and secure than she was entitled to, and that it was immaterial whether the plaintiffs or the defendant considered the depth safe. The plaintiffs claimed that they were entitled to charge for the work done as on a *quantum meruit* (*i.e.*, practically, by measure and value) but the Official Referee disallowed the claim, and held that as the work done was not according to the specification, the builders were not entitled

to the contract price of 264*l.* nor to remuneration on the basis of a *quantum meruit*. This decision was reversed on appeal, the Court (Ridley and Sankey, J.J.) holding that the plaintiffs had not abandoned the work, but had completed it; that it was not wholly different from what was agreed to be done; that it was of actual benefit to the defendant; and that the plaintiffs were entitled to recover for the work done on a *quantum meruit*. In the Court of Appeal the decision of these two judges was affirmed. Lord Justice Pickford said: "I cannot accept the proposition that if a man agrees to do a certain amount of work for a lump sum, every breach which he makes of that contract by doing his work badly or by omitting some small portion of it is an abandonment of his contract or is only a performance of part of his contract, so that he cannot be paid his lump sum. It seems to me that would be a performance of the contract, but doing some part of it badly, and that seems to me to be the case here."

It is interesting to notice that although American courts of justice generally follow the rules of English law in this particular there is a divergence. In most States of the Union, it is held that "Substantial performance" is sufficient to enable a builder to sue for his money, and the Supreme Court laid it down, so long ago as 1869, "that in the adjudication of controversies arising out of building contracts where payment depends on completion small differences in the dimensions wherein the building constructed and the terms of a contract may, under many circumstances, be overcome by a reasonable application of this rule 'substantial performance'."

As shown in the earlier part of this article, the English courts evince no disposition to adopt this American rule, and in the best interests of business it may be hoped that it will never be adopted.

Having regard to the state of the labour market at the present time, and to the difficulty of relying on the prices of materials remaining constant, definite quotations are not often given; but it would seem to be better from the employers' point of view to consent to the erection of a work at measure and value than to agree to pay a sum for which the contractor may or may not be compelled to complete.

NOTES.

THE PROPOSED BRITISH EMPIRE EXHIBITION, 1923.

ALTHOUGH the year 1923 is still some time ahead we are glad to note that energetic steps are already being taken to get together in that year an exhibition in the neighbourhood of London, representative of the whole of the British Empire. This will be the first occasion on which the whole Empire will have been embraced by such an undertaking. The nearest approach to the present scheme was the Colonial and Indian Exhibition of 1886, which, however, excluded the Mother Country. Since the date of that exhibition the Empire has increased in territory by nearly 5,000,000 square miles, and its population by 130,000,000. Trade has enormously developed, exports in 1920 having been nearly sevenfold what they were in 1886; in imports there has been much the same expansion. The idea of the present exhibition originated with Lord Strathcona. The scheme is warmly supported by the Colonies, cordial approval having been expressed by leading statesmen of Australasia, Canada, South Africa, India, &c. His Royal Highness the Prince of Wales is President of the General Committee, and is taking energetic steps to arouse interest in the project. The exhibition will be held in grounds secured at Wembley Park; the site is a very pleasant one which should lend itself well to attractive treatment. Mr. J. W. Simpson, past president of the Royal Institute of British Architects, and Mr. Maxwell Ayrton, F.R.I.B.A., are architects to the exhibition, and Mr. E. O. Williams, Assoc.M.Inst.C.E., is consulting civil engineer. Four sections of the exhibition will be of greater interest to our readers than the rest, viz., Section B, Raw Materials of the Empire; Section C, Communications of the Empire; Section D, Machinery and Implements of the Empire; Section E, Manufactures of the Empire. In this group there will be represented mineral and other products, all classes of engineering, and industrial processes. Congresses and lectures will be arranged in connection with the exhibition. Every effort is to be made to make the exhibition as useful as possible from the scientific side.

THE PORT OF LONDON AUTHORITY.

Although this year has not been a favourable one for shipping, the figures for the Port of London for 1920 must be considered as fairly satisfactory, as they showed a distinct tendency to expand to something like pre-war level. It is true that the net tonnage of vessels arriving and departing with cargo amounted to rather less than 33,000,000, compared with 40,000,000 tons in 1913, yet compared to the dwindling figures of the war years, reduced to 14,500,000 tons in 1918, the results for 1920 will be admitted to be satisfactory. Immediate recovery of course was not to be expected, and it is only to be regretted that the unstable conditions of the past months have put a check to the complete return of the port to conditions of pre-war activity. The net tonnage of shipping which paid river tonnage dues during the 12 months ending March 31, 1921, amounted for "foreign" shipping to nearly 18,000,000, an increase of 17·2 per cent. on the amount of 1920. In coastwise shipping the increase was one of 14·2 per cent., the quantity in 1921 being 6,483,374 tons. The shipping using the wet docks of the Authority amounted to 62·3 per cent. of the total, the "foreign" shipping showing an increase of 14·5 per cent. and the coastwise of 20·3 per cent. over the figures for 1920. Some 2,425,479 tons of shipping used the Authority's dry docks. The values of the imports and exports of the United Kingdom, excluding coastwise goods, was practically 3,490,000,000 pounds sterling for 1920. Of this, trade via London represented rather more than 1,005,000,000 sterling, this port being surpassed by Liverpool by about 86,000,000. It will be remembered that in our issue of July 1, p. 3 *ante*, we gave an illustrated account of the large extension to the Authority's dock accommodation, recently completed.

THE BRITISH ASSOCIATION.

THE influx into Edinburgh of members of the British Association will temporarily help to compensate the Scottish metropolis for the decrease in population since 1911. The census of this year reveals a loss of 3,765 inhabitants, the population amounting now to 420,281. The other large towns of Scotland, with the further exception of Aberdeen and Dundee, all cities which the Association has visited, have added to their population, as the country itself has; but the total gain of the last ten years, 121,384, represents only 2·5 per cent. of a population of 4,882,288 people, and is the smallest so far recorded.

As regards Edinburgh, the 2,593 British Association members now on the list will not all contribute to swell the population. For about 800 of these are more or less local members. The response is gratifying, and considering that the railway fares are still high and that the former special railway facilities are not yet available again, the attendance is satisfactory. The numbers may be expected to increase, moreover. Yet 1921 will not find it easy to emulate 1892. In those former days the Association could almost rely on the presence of Stokes, Kelvin, Fitzgerald, to think of Section A only, and the absence in 1892 of Rayleigh and of Rowland was exceptional. A large number of distinguished scientists had come from abroad, including Helmholtz and others; the foundation of a National Physical Laboratory was a subject for discussion at that meeting. Foreign scientists are not missing this year either; Professor R. W. Wood, successor to Rowland in Baltimore, will be following his predecessor's example also by coming over; Professor Michelson is also expected once more; we shall have to mention other names.

Many a man surnamed Scotus has attained fame in the world. Michael Scot, the wizard, astrologer to the last Hohenstauffen Emperor Frederick II (died 1250), was born near Edinburgh. He is first mentioned in the excellent book on "Edinburgh's Place in Scientific Progress," which the local committee have been preparing, and which contains portraits of many famous men. John Napier (1580 to 1663), the discoverer of logarithms, is known as Napier of Merchiston, a district of Edinburgh; his old castle now forms part of a school. John Playfair, John Leslie, David Brewster, J. D. Forbes, Rankine, G. Chrystal, James Thomson and Guthrie Tait were all Edinburgh professors; Tait and Clerk Maxwell were school-fellows there, William Nicol, of prism fame, was an Edinburgh naturalist. Joseph Black, Lyon Playfair and Crum Brown are among the great chemists of the city; Sir James Dewar brings the line of Edinburgh men up to date in chemistry, as Professor E. G. Coker does in engineering.

Though Edinburgh cannot claim to be a great engineering city, and iron and steel works have still to be established there, Professor Hudson Beare, who contributes the engineering section of the volume referred to, considers that this development is approaching. Credit for Edinburgh he claims particularly with respect to the origin and early development of steam navigation and of railways, and to the invention of the steam hammer, coupled with the names of William Symington—educated at least in Edinburgh, if not born there—Patrick Millar and James Nasmyth. The professorship of engineering at the University of Edinburgh only goes back to 1868 and to Fleming Jenkin; a pupil of Jenkin, Sir J. A. Ewing, is now Principal of the University. The development of industrial chemistry has largely gone parallel with the drug industry. Brewing and alcohol distilleries are less characteristic of the district than the oil shale distilleries which James Young, born in Glasgow in 1811, originated. The medical school, which has long made Edinburgh famous, dates back to Sir Robert Sibbald (1641 to 1722), if not to the Michael Scot above alluded to.

The Reception Room is in Parliament Hall, and the Section Rooms are accommodated in buildings of the University, much as in 1892, when there were only seven sections instead of the present thirteen, and we are afraid the joint discussions between several sections will suffer somewhat from the fact that one may have to spend ten minutes and more in walking from one section to another. The addresses and lectures are delivered in Usher Hall, where, on Wednesday evening, Professor W. A. Herdman, the president of the past year, resigned the chair in favour of Sir T. Edward Thorpe, D.Sc., F.R.S., emeritus professor of chemistry at the Imperial College of Science, South Kensington, late Government chemist. Sir Edward also represents Great Britain on the International Committee for Atomic Weights, to which he referred in his address. The other general officers remaining are the treasurer, Dr. E. H. Griffiths, F.R.S., successor to the late Professor John Perry, and the general secretaries, Professor H. H. Turner, F.R.S., and Professor J. L. Myres, D.Sc. Sir T. Edward Thorpe was unfortunately prevented from being present on Wednesday evening, and his Presidential Address was read in his absence by Sir Alfred Ewing.

ADDRESS BY THE PRESIDENT, SIR EDWARD THORPE.

The invitation circular, sent to members of the British Association in June, had announced that the President would deal in his address with "Some Aspects and Problems of Post-War Science, Pure and Applied." That was his subject, but he did not give the address a title.

Dwelling in his introduction upon the previous visits of the Association to Edinburgh, to which we drew attention in a preliminary article on page 288 of our issue of August 19, Sir Edward remarked that, though the first three meetings of the Association had been held at York (1831), Oxford and Cambridge respectively, the Association might, as an historical fact, be said to have had its origin in the metropolis of Scotland in 1834. In support of this claim, Sir Edward referred to the popular appreciation of the activities of that meeting, to the range and character of the proceedings and to the manner in which the funds were employed. The importance of joint discussions of the several sections, now a permanent feature, had then already been pointed out by Professor Sedgwick, the President of the preceding year. At the second Edinburgh meeting of 1850, the President,

Sir David Brewster, had urged the need of national support of research. Sir William Thomson, the President of the third Edinburgh meeting of 1871—the first Sir Edward had attended as one of the secretaries of the chemical section—had again insisted that experimental research ought to be made an object of national concern, whether we looked to the honour of England, or to the vast economical advantages of establishments promoting physical science.

These reminiscences led Sir Edward to a summary of the useful activities of the Department of Scientific and Industrial Research, based upon information for which he was indebted to Sir Francis Ogilvie. Almost all the boards and organisations for promoting research are now under this department. The Geological Survey Board, controlling also the Museum of Practical Geology, stands apart. But the Building Research Board, the Food Investigations Board, the Forest Products Research Board, the Fuel Research Board, the National Physical Laboratory and the Mine Research and Mine Rescue Apparatus Committees are maintained by this department or attached to it. The department also directs inquiries into the preservation of antique objects deposited in the British Museum, and is concerned with the gauging of rivers and tidal currents; four co-ordinating boards—for the problems of physics, chemistry, radio research and engineering—organise scientific work in connection with the fighting forces to avoid overlapping. The department is further empowered to assist learned societies and institutions in their investigations. Grants are made to Research Associations, formed voluntarily, from a fund of a million pounds, subject to the approval of the Articles by the department and the Board of Trade; the grants are at the rate of pound for pound raised by the Association, or, in the case of "pivotal" industries, at a higher rate, and are free of income tax. The Board of Trade has so far issued 24 licenses to such Associations. The department has further established a Records Bureau, responsible for abstracting, filing and collating, which enables the department to prevent repetition and overlapping of research and to make full use of it. Of the 40 patents taken out by the department jointly with the inventors and interested bodies, nine have been abandoned.

In the second part of his address Sir Edward took up the subject of Lord Kelvin's presidential address of fifty years ago, the development of the molecular theory of matter. Unlike the chemists, Sir Edward said, Kelvin had never been in the habit of evading questions as to the hardness and indivisibility of atoms by virtually assuming them to be infinitely small and infinitely numerous, nor had he realised, with Boscovich, the atom "as a mystic point endowed with inertia and the attribute of attracting and repelling other such centres." Coming then to our days Sir Edward stated that the hydrogen isotope H_3 of J. J. Thomson seemed to be an integral part of the atomic structure, and different apparently from the substance of mass 3 which Rutherford had isolated by the disruption of oxygen and nitrogen and which he regarded as an isotope of helium, itself built up of four hydrogen nuclei together with two cementing electrons. The atomic nuclei of elements of even atomic number would appear to be composed of helium nuclei only or of such nuclei with cementing electrons, whereas those of elements of odd atomic number were made up of helium and hydrogen nuclei, together with cementing electrons. In the case of the lighter elements of the latter class the number of hydrogen nuclei associated with the helium nuclei was three (except in the case of nitrogen where it was two). The frequent occurrence of this group of three hydrogen nuclei indicated that it was structurally an isotope of hydrogen, with an atomic weight of three and a nuclear charge of one, identical, it was surmised, with the hypothetical nebulium from which our "elements" were held by astro-physicists originally to be produced through hydrogen and helium.

Having briefly and uncritically summarised Aston's remarkable work on isotopes, with which our readers are familiar,* the President explained chemical combination and valency on the lines of J. J. Thomson, G. N. Lewis and Langmuir. The number of electrons in an atom is equal to the atomic number of an element. Eight electrons can be accommodated on an outer sphere or layer of an atom. Lithium has one such electron in this layer, glucinum (beryllium) two, boron three, fluorine seven, neon eight; those elements belong to the first octave of the periodic law. Sodium has nine electrons; eight are in the first layer, the ninth goes into a second layer further out; magnesium and aluminium send their tenth and eleventh electrons respectively into the second layer, and so on for the other elements of the second octave. When elements combine, they are linked up by the outer electrons. Neon having already eight electrons on its sphere is saturated and does not form compounds. Fluorine has seven electrons; it can therefore take up one more, and is considered monovalent. Oxygen has six electrons in the outer layer; it can therefore take up two more electrons, and is considered divalent. But its six electrons can themselves fill up six vacant spaces in other atoms, and oxygen has hence also a valency six. Similarly nitrogen, with five outer electrons, forms compounds in which it has the valencies three or five. Thus modern developments lead back to the views of Abegg and Bodländer that every element has two valencies, a direct and a residual valency, the sum of the two being always eight.

While the possibility of many isotopes, which the chemist could hardly hope to isolate, seemed to make for great complexity, it might, Sir Edward explained, ultimately lead to simplicity, and exact determination of the atomic weight became more important than ever. The work of the International Committee on Atomic Weights should, therefore, be re-organised and its aims be extended. Simple calculation of the atomic weight might appear possible on the assumption that the integer rule held mathematically. But it was almost certain that the integer rule could not hold, owing to the influence of "packing." The little differences, in fact (*i.e.*, small fractions in the atomic weight), might make all the difference, as in the case of gases which all departed from the mathematical gas laws. This negation of the much-pressed argument, that all atomic weights must be integers, will recommend itself to many chemists and scientists generally.

The concluding portion of the address was devoted to a denunciation of the German barbarous warfare by poison-gases. Sir Edward admitted that chemical warfare had not wanted for advocates. It had been argued that poison-gas was less fatal and far less cruel than other instruments of war and, as a method of conducting war, more humane than preventive medicine, which had increased the army unit, free from epidemic and communicable disease, from 100,000 to a million. Preventive medicine would be able to fight its own case. But he trusted that the "Association would set its face against the continued degradation of science in thus augmenting the horrors of war. It could have no loftier task than to use its great influence in arresting a course which is the very negation of civilisation."

At the conclusion of the reading of the Address by Sir A. Ewing, a vote of thanks was moved by the Lord Provost of Edinburgh. This was seconded by Sir James Dewar, and passed in the usual manner.

Elsewhere in this issue we reproduce some of the papers read before Section G of the Association yesterday. The discussions, with the later proceedings, will be dealt with in future issues.

THE IRON AND STEEL INSTITUTE.

THE Autumn meeting of the Institute took place on Monday and Tuesday last, the 5th and 6th inst., in the building of the Comité des Forges de France, 7, Rue de Madrid, Paris, Sir Hugh Bell, Bart., past president, occupying the chair, in the absence of the president, Dr. Stead, through illness.

The proceedings were opened by Mr. François de Wendel, president of the Comité des Forges, who extended a hearty welcome to the visitors and expressed the great pleasure which the French metallurgists felt in receiving their British colleagues. Such a meeting as the present one had not taken place for over 20 years, namely, since 1900, on the occasion of the last Paris exhibition, when the speaker was Mr. Robert de Wendel, who then welcomed the guests and thanked the Institute for the award of the Bessemer medal to Mr. Henri de Wendel. He (the speaker) recalled the cordial relations which existed then between the metallurgists of both countries, and which had since developed still further, consequent upon the late war. The two countries had fought shoulder to shoulder, and for them the term "friend" had acquired a new signification.

In alluding to the visits which the members were going to pay in the eastern districts of France, he appealed to them not to limit their studies to the technical side only, but to consider also the political factors which had intervened, and to look into the vast economic problems which now faced those districts. There had occurred differences of opinion between the Governments of the two countries, though he would not enter into that, but he would ask all the English friends to endeavour during their stay in France to study the French view of the situation. Reconstruction in the devastated regions of France was still far from complete, and that reconstruction which so far had been carried out had been carried out by French capital. On the other hand, practically every German works was now running at its full capacity, and Germany refused to apply the peace treaty and to take the responsibility for the war which she had started. He knew what Germany could do; he felt anxious and his countrymen were all as anxious as he; protection was needed and in this sentiment there was really no vestige of militarism. France could in no way afford to fight to win a victory a second time. In closing he expressed the hope that the French and British metallurgists now meeting would be induced to talk over together points of general interest; the cordial friendship which existed between them was one of the best guarantees for the peace of the world.

Sir Hugh Bell referred to the illness of Dr. Stead, and added that he (Sir Hugh) had been invited by the council to take his place. He moved that a telegram be sent to Dr. Stead expressing regrets at his absence and wishes for his speedy recovery. This motion was carried unanimously. Sir Hugh then thanked Mr. François de Wendel for his kind words of welcome, although the Institute was always sure beforehand of a cordial welcome on the part of their French colleagues. He (Sir Hugh) recalled that in 1869 he had the pleasure of meeting Mr. de Wendel's grandfather for the first time and heard from him on that occasion that the ground on which they were then standing, in close proximity to the de Wendel works, would be that on which battles would be fought in a not far distant future. That prediction came true less than two years after. Sir Hugh looked back with pleasure to many years of friendly acquaintance with the family of Mr. de Wendel, and also with another great French family, that of Mr. Schneider.

It would be remembered, continued Sir Hugh, that the Institute was on the point of holding the autumn meeting in Paris in 1914, and all preparations made, but circumstances of bitter memory had intervened. The war had caused grave disasters to France and also to the world at large, disasters the extent of which we were not even yet fully aware. It was due to us and to our French colleagues to work together to repair this damage. There was no use disguising the facts. He (Sir Hugh) commended the admirable discretion with which Mr. François de Wendel had spoken. The meeting was not the place for a political discussion. He would like to add, however, that it was natural there should be differences of opinion between our two countries. The war had been nothing but an evil, but it was to be hoped that some good might, perhaps, still come of that evil, and "let us look at each other," added Sir Hugh, "in a different spirit from that which prevailed before." France will take now a position in metallurgy different from that which ruled formerly, and he could assure their French

* See ENGINEERING, February 18, 1921, page 203.

colleagues that nothing would be wanting on our side to contribute to making that situation as profitable and advantageous for her as possible. Mr. de Wendel had referred to the German population on the other side of the French frontier; our eyes were opened to that; let us hope (he added) that the eyes of Germany were open also, that she had learned that of all the bad ways of developing commercial activity, war was the worst, and that the best way was by all round co-operation.

Sir Hugh expressed the deep sympathy which the meeting had for France in her difficulties, and the hope which animated all the visitors that she would speedily recover from the wounds from which she was suffering and attain to the prosperity which she so richly deserved. Metallurgy was, unfortunately, the chief instrument of war, but it was also the chief instrument of peace. In closing his remarks, Sir Hugh stated that during the present year our French friends were going to celebrate the jubilee of one of the Institute's honoured members of council, Professor H. Le Chatelier; the Council had decided to contribute to the funds which were being raised for the purpose, and Sir Hugh took that opportunity for offering Professor Le Chatelier his own congratulations and those of the Institute.

Professor Le Chatelier, who replied in French, said he first met Sir Lowthian Bell at Middlesbrough in 1868, and it was at that date that he first gave attention in any definite way to metallurgy. Later, he met other British metallurgists who, like Sir Lowthian, were friends of his (the speaker's) father. During many years, his scientific work led him to follow a somewhat different path, the study of high temperatures, and it was only comparatively late in his career that he found out the effect which these early meetings with British metallurgists he referred to were to have upon his activities. It was at this comparatively late date that he took up metallurgy in earnest and founded the *Revue de Métallurgie*. He was very glad now to come in contact again with the son of Sir Lowthian Bell, and thanked him for his kind reception.

Sir Hugh Bell then presented the Bessemer gold medal to Mr. Charles Frémont, the well-known French metallurgist, who has carried out many technological researches, and in the early days with comparatively rudimentary appliances. In 1890, Mr. Frémont published his first work on the technics of forging. He then applied cinematography to illustrate the work of the striker in forging operations, an illustration which was reproduced and dealt with in 1906 by the Société d'Encouragement pour l'Industrie Nationale. Later, he recorded élastic deformation as applied to tensile tests, and established the relations which exist between shearing tests and tensile tests. His researches led him to deal with the measuring of the brittleness of metals by breaking a test specimen in one single blow by a falling weight, then registering the *vis viva*. In regard to the tensile test more particularly, Mr. Frémont devised a means of recording the limit of elasticity by the means of lines appearing on the smooth surface of the test piece. These are only a few brief indications of the activities displayed by Mr. Frémont in the realm of technics, one direct result of which has been a marked decrease in the number of accidents following upon the failure of iron and steel parts of machinery in every-day use. He also carried out work on riveted pieces, and his testing machine for files has been referred to in a paper read at a former meeting of the Institute.

Mr. Frémont briefly thanked the president and the members for the award granted him.

The Iron Ore Deposits of Eastern and Western France.

The first paper taken was the one having the above title, by Mr. P. Nicou. In his absence, it was read by the secretary. Mr. Nicou, in his opening remarks, refers to a former paper of his on the same subject which was to have been read at the autumn meeting of the Institute of 1914. We dealt with the subject at the time (see ENGINEERING, vol. xcviii, pages 421, 511 and 590). The present paper gave the iron ore resources of Lorraine, and entered into the possibility of exporting part of this ore to Great Britain. The resources of French Lorraine are estimated at 5,000 million tons, and, to take only one grade, the Briey ores of the grey seam yield, on a sample dried at 110 deg. C., 36 per cent. to 42 per cent. of iron, 9 per cent. to 14 per cent. of lime, and 4 per cent. to 7 per cent. of silica, the average moisture of the undried ore being 8 per cent. to 11 per cent. The iron ore beds of Normandy are better located from the point of view of exports to this country. The highest grade of Normandy ores shows an analysis 50 per cent. to 55 per cent. of iron, 10 per cent. to 12 per cent. of silica, 3 per cent. of alumina, 2·5 per cent. of lime and magnesia, 0·6 per cent. to 0·7 per cent. of phosphorus, and 3 per cent. of water. Ores of these latter beds have already been exported to this country in exchange for coal. Somewhat extensive beds of hematite or magnetite ore exist in Anjou and Brittany, also in the west of France; ores from these beds as from those from Normandy mines have already been shipped to this country.

Notes on the Iron Mines in the Briey Region damaged during the German Occupation and their Reconstruction.

These notes, which were not in printed form and were communicated by Mr. A. Guillain, were then read in abstract by the secretary. They did not deal with the Thionville field, which continued to be worked during the war by the Germans, nor with the Nancy field which was not invaded and continued to be worked by the French, but only with the Briey field which was invaded by the Germans in 1914 and was liberated in November, 1918. In a preceding issue, when describing the German devastations to the French metallurgical work (see ENGINEERING, vol. cxi, page 670), we gave a few examples of the way in which the enemy had worked and damaged some of the mines in question. The paper by Mr. Guillain gave a translation of German secret orders, issued in July, 1917, for the destruction of one mine, the Anderny mine, in case of a break through of the Allied armies.

Professor Lewis, who opened the discussion, said he would confine his remarks to the paper by Mr. Nicou. In the first place, he desired to express the gratitude of British metallurgists for the very complete résumé it gave of the iron resources of France. In regard more particularly to the deposits of Western France, Mr. Nicou had stated that the dip was considerable, varying from 30 deg. to 85 deg., and except in the St. Remy region, the bottoms of the synclines were unknown. This statement was made on the basis of observations made by Mr. Cayeux, among others. He, the speaker, had carried out measurements at Segré, and had been able to arrive at the definite opinion that in that field the bottom of the syncline was at a very great depth. He could therefore corroborate Mr. Cayeux's statement.

In the opening sentences of his paper, the author had said that Great Britain remained, as in 1914, dependent upon supplies of foreign ores. On that point he differed from the author entirely. In what he would term the pre-steel age, Great Britain produced all the ores she wanted. But as time went by, new processes of manufacture were followed, the railways were introduced, the navy developed, and our export of coal rendered the importation of ore both easy and cheap. This importation of ore reached high figures, and this had led the continent to believe that we were short of ores. The simple fact was that it was cheaper for us to import ores, and that explained why we had adhered so long to the acid process. Then the late war came, making it impossible for us to continue importing, and we developed our home production.

Before the war we worked mostly the acid process, whilst we were now going in more and more for the basic process. In the matter of ores we were rather at a disadvantage. Whilst in France the mines were the property of the State, and were determined accurately, with us they were determined only as the need arose. Our resources were not known so accurately as were the French resources. But the British Geological Survey had issued statements which showed that in mesozoic ores we had 3,400 million tons, as against the 5,000 million tons of French Lorraine; and our best were similar to the Briey ores, having 47 per cent. of iron and 14 per cent. of silica, figures which were not very different from those of Briey. We also had besides a very great quantity of coal measure ores, which would come in useful, but were difficult to work. He did not mean to say we should not import ores, but thought that what we should have to seek was rich ores, the working of which required a minimum coal consumption.

Mr. H. K. Scott also considered that the Institute was indebted to the author for his very complete paper, but would have liked to see this illustrated by a map. The author had said that the ores of the Lake Superior region of the United States were only richer by 1 or 2 per cent. of iron than the Briey ores. He, the speaker, believed this statement was erroneous. The remarks made by Professor Lewis were comforting, but he, the speaker, was not reassured by Professor Lewis's endeavours to make out a strong case for our British ores.

Mr. François de Wendel, in answer to a remark by Mr. Scott said it was thought in France that the bed was enriched at the fault. Mr. Guillain had studied the point, but as yet there was no definite proof that such was the case.

Sir Hugh Bell said the meeting was obliged to both authors for their contributions. We had imported ores because we found it profitable to do so, and now we were beginning to find it profitable to work our own ores. Progress in metallurgic practice had altered the conditions under which importation could be carried on. The location of the mines, melting plant and harbours, formed important factors to take into consideration. But the fact that the iron trade was essentially an international trade should never be lost sight of; it was on that fact that he, the speaker, relied for the future of the trade, and the papers were important ones in the sense that they opened out before us a wide vista.

On the members reassembling on Tuesday morning last, the chairman announced that the next president of the Institute would be Mr. Francis Samuelson.

On the Position of the Metallurgical Industries of Northern and Eastern France; Their Destruction and Reconstruction.

The first paper taken at the Tuesday morning meeting was the one having the above title, by Mr. Guillet, who delivered it in French, illustrating his remarks by a series of lantern slides. His object, he said, was to give the meeting an idea of the formidable destruction of French works, wilfully carried out by the Germans, and also an idea of the reconstruction so far effected by France. He recalled to the meeting the fact that the British journals, notably the technical journal ENGINEERING, had dealt with the matter, the latter having recently published a series of articles covering the mines, steel works and railways, which series had been written by Mr. Lemmy, a member of the Institute, whose name was well known by the numerous readers in France of that important London technical publication. (See ENGINEERING, vol. cxi, pages 366, 494, 604, 670, 782.) The *Revue de Métallurgie*, in France, had also published during the past months a series of articles on the same topics, articles which had recently been issued in book form, and Mr. Guillet expressed a hope that this latter would also find many readers in the United Kingdom. Since we have so recently dealt with the various points which form the subject of Mr. Guillet's communication, we shall not follow his exposition at the meeting and shall ask our readers to refer back to our articles mentioned above.

Sir Hugh Bell thanked Mr. Guillet on behalf of the members for his paper, which was of a nature such that it required no discussion. He added that he had seen all the stretch of country from Belgium down to Verdun in the early months of 1919. There was nothing more striking than the vast extent of the destruction he witnessed over a line of 400 miles in length and over a breadth of about 40 miles—it seemed as though the damage caused could never by any possibility be made good

again. French enterprise had, however, stepped in and the reconstruction of the invaded districts was being proceeded with. All our condolence was due to our French colleagues and, at the same time, our most hearty congratulation for the way in which they had carried out so far and were still proceeding with the reparation of their losses. He thanked Mr. Guillet again for his interesting communication, and he would ask him to convey to all the works in the evacuated districts the felicitations of the meeting on the way they had tackled the extremely difficult problems which confronted them.

The late Professor D. Tschernoff.

At this point Sir Hugh Bell announced that news had been received to the effect that Professor Tschernoff, one of the Honorary Vice-Presidents of the Institute, had died. He was afraid the news was true; it was impossible, however, to obtain confirmation or to trace any member of his family. He recalled the work carried out by the deceased, notably in regard to the critical points of steel. On the invitation of the chairman, Sir Hugh Bell, the members stood a few instants in their places to mark their sorrow at the unfortunate end of this distinguished savant.

An Investigation of Hot Drawing on the Mandril.

The second paper dealt with "An Investigation of Hot Drawing on the Mandril," contributed by Mr. Schneider, past president. It was read in abstract by the secretary, and was not discussed. It is of a nature which does not allow of a brief abstract at this place, and we shall publish it in part in a forthcoming issue.

An Experimental Investigation of the Mechanical Properties of Steels at High Temperatures.

The third paper was that having the above title, by Mr. E. L. Dupuy. It was read in abstract, and we commence its reproduction on page 391.

Colonel Belaïeff took the opportunity which the paper offered for calling the attention of all interested in the subject to the very high temperatures obtained by the author. He (the speaker) had been associated in research work eight or ten years ago with the author, and it was always well known that the latter was a good experimentalist. The results he had given in his paper were expected results, but it was important that he had published them, and had confirmed their expectations.

Mr. Guillet said the work of the author was a most interesting one, and he would like to see it generalised upon the methods which he (the author) had followed. The difficulties which Mr. André Le Chatelier, Mr. Charpy, Dr. Rosenhain, among others, had met in similar work were well known, and the author had thrown light upon these. He (the speaker) would like the work to be pursued on special steels. There were many branches of industry at the present time which were at a standstill by reason of the effect which high temperatures had upon metals and mechanical parts of machinery. The problem of the gas turbine, for example, might be solved if there were available a metal highly resistant to heat. He (the speaker) recalled the work he had done in the same field, and recorded in the *Revue de Métallurgie* and in the Proceedings of the Société des Ingénieurs Civils de France, where he had drawn attention to the researches made at the Commentry-Fourchambault establishments on alloys of iron with nickel, chromium and tungsten, resisting temperatures of 750 deg. and 800 deg. centigrade. At the said establishments, tensile tests were first carried out, but Mr. Chevenard did not limit himself to these tests, but also made viscosity tests, using a wire at a high temperature to which a weight was attached. What was needed was to carry the metal up to those high temperatures, and to leave it exposed to them for days at a stretch, without fracture. He thanked the author for having made known the remarkable results he had obtained, and asked that the work might be continued, not only with ordinary steels but also with special steels, their behaviour being shown after prolonged heating.

Dr. W. H. Hatfield stated that the question of stress as affected by increased temperature was one of importance in the case of internal-combustion engines. At his (the speaker's) works they gave great attention to the matter and examined steel at ascending temperatures, from 300 deg. C. up to rolling and forging temperature. He was generally in accord with the author. The Institute had not printed the author's tables, and it was important that these should be added to the paper. He asked the author how many determinations he had made on each steel. There was one matter to which all should give attention, the work was a very important work, and some unification in the method of testing should be introduced. The author heated at the rate of 20 deg. per minute, which meant that the temperature of 1,200 deg. was reached in 1 hour; this, Dr. Hatfield thought, was rather fast, and he himself took 2 hours from 70 deg. upwards. The author apparently maintained the temperature during 5 minutes, whilst he (Dr. Hatfield) maintained it at least for half an hour. For these reasons it was difficult to compare results. The data in the preceding paper, by Mr. Schneider, were also important and he asked Mr. Cohade, from Creusot, who was present, to say whether the steel dealt with was mild or high carbon steel, as this had an important bearing upon the matter. (Mr. Cohade will reply by writing.)

In the course of his brief reply, Mr. Dupuy, in answer to Dr. Hatfield, said he had made between 40 and 60 determinations in each steel, and his curves were drawn exclusively on the points actually determined. In regard to the speed of heating, he knew that the speed he had adopted was high, but he had numerous tests to make; if he had taken longer to heat, his determinations would have been less in number—he had to make a sacrifice in one direction or the other.

The "Characteristic Curves" of the Heat Treatment of Steels.

The last paper taken was the one by Mr. A. M. Portevin and P. Chevenard, having the above title. It was read in abstract by the latter. We shall reproduce it in a future issue.

The discussion was opened by Mr. Guillet, who said that this communication to the proceedings of the Institute drew attention to the vast progress made in the *étude* of the phenomena occurring in the heat treatment of steel. The "father" of all special steels was the Hadfield manganese steel, the hypertempered steel par excellence. At the Congress of Physics which was held in 1900, Sir Roberts Austen, a friend of Mr. Osmond, had said that there was no more important operation than that of tempering metals, and called attention to the most outlandish liquids which were recommended for the purpose. We had, fortunately, long passed those antique methods. He (the speaker) drew the attention of the meeting to the work of Messrs. Osmond, Le Chatelier, Portevin, Dejean, among others, and to the Chevenard dilatometre which allowed of the accurate determination of critical points. The heating of certain mechanical parts previous to their hardening was a most delicate operation, milling cutters were of the number, and he (the speaker) had dealt in detail with the question in the *Revue de Métallurgie*, pointing out that an excellent mode of procedure was to heat these cutters in cast-iron turnings.

Sir Robert Hadfield thanked the author for his excellent paper, and pointed out that metallurgy was greatly indebted to French scientists for the progress made, among other branches, in the manufacture of special steels. The British metallurgist who had assisted at the two meetings had been most happy to be surrounded by a noble band of workers of French nationality, such for example as their old friend, Mr. Pourcel, formerly of the Terre-Noire works, to whom, together with Messrs. Euvérte and Gauthier, the world was greatly indebted for their early pioneer work. Sir Robert mentioned that on the preceding day he had called at the Ecole Polytechnique, where he had seen the Portevin and Garvin apparatus, and a most complete series of instruments for the accurate control of the heat treatment of metals and other operations; with these, the various operations were effected with mechanical accuracy. He was only afraid that in future diagrams may be made probably 40 feet in length. At all events, our work was improving, and a direct result would be an increase in the demand for steel.

On the motion of the chairman all the authors received the thanks of the meeting for their contributions. Votes of thanks to the Comité des Fonges and to the chairman concluded the proceedings.

We may add that on Monday a deputation formed of members of the Council and of ordinary members placed a wreath upon the tomb of the Unknown French Soldier at the Arc de Triomphe. On the same day, the President of the French Republic graciously received a deputation from the Council. On Tuesday a deputation of French and English members visited the cemetery of Passy, and placed a wreath on the grave of the late Sidney Gilchrist Thomas.

The members later divided into three groups, and visited works in Lorraine, the Creusot and St. Chamond establishments, and works in Normandy.

LITERATURE.

Collection and Disposal of Municipal Refuse. By Rudolph Hering, D.Sc. New York City, Past President of American Public Health Association, and Samuel A. Greeley, Chicago, Ill., Member of American Public Health Association. New York and London: McGraw-Hill Book Company, Inc. [Price 42*s.* net.]

Among the disadvantages that arise from the tendency of the population to collect in congested centres is the ever increasing difficulty of disposing of the waste material and unsightly refuse that are the product of domestic life. Those who recommend the healthiness and prudence of a return to the country side, might well urge as an inducement the inconvenience that arises from the accumulation of refuse within a small area, and the expense entailed in its removal or destruction. An army of men is engaged in the work of collection and disposal and these are of necessity withdrawn from more productive labour, while the money capitalised in providing the necessary machinery is by no means small. It is perfectly true that the same undesirable refuse collects in small communities, but the disposal of it is easier and the risk of infection smaller when the objectionable material is distributed over an area larger in proportion to the number of inhabitants. Collection and destruction have not to be so efficiently organised, and it is generally practicable to allow each householder some latitude in the choice of method of disposal. But in cities the problem of the disposal of solid refuse increases in urgency and difficulty as the city itself increases in size. The contribution daily from a single family seems a trifling amount, averaging about three pounds per head, throughout the year, but in a city with a population of one million, this implies that some 450,000 tons of waste material, ashes, vegetable garbage, and discarded trifles have annually to be harmlessly destroyed or economically treated. Cities of this size and larger are rapidly increasing in the States, and care for the present, as well as proper provision for the future are exercising the attention of the town authorities. It is intimated that the frequent changes in the personnel of the municipal controlling bodies increases the difficulties of finding a correct solution, but that is a question of internal politics and does not affect the object of the authors of the volume under notice.

That object is to record and discuss American practice in the disposal of American refuse. References are occasionally made to European experience, but American authorities supply the special information and indicate the directions that imperatively call for attention, while it is especially sought to increase more general interest in the subject throughout the States, and to induce the preparation of more exact statistics for future guidance. Seeing that this question of refuse destruction must have attracted attention from the time that man settled in permanent dwellings, it is strange that detailed information is so scarce and unreliable. But the authors are inclined to rule out all European methods on the ground that these have become standardised and unprogressive, incapable of

furnishing guidance, owing to the long settled state of the cities. The refuse problem in its modern form, however, is of quite recent growth, whether in Europe or America, for it was not till sanitary science acquired prominence that this branch received the attention it deserves. The correct explanation of the want of accurate information is due to the fact that the subject was at first only imperfectly and unintelligently studied. Experiments were undertaken on insufficient data and proved disappointing. The literature of the question, as the authors admit, is not satisfying. The attitude of the public and of the City officers has been one of indifference; failing to recognise that the problems incident to final disposal are largely engineering in character, and therefore only to be satisfactorily handled by engineers, officers have not been properly trained and encouraged. It has been no light task to construct order out of materials that were unmethodically collected and often marked by discouraging lacunae and efficiency. For ten years the authors have been engaged in collecting, sifting, and systematising information with the view of bringing about improved methods in working and design. We congratulate them on the result, and believe that they are justified in concluding that the whole subject of refuse collection and disposal both theoretically and practically has passed the period of speculation and experiment. "With every prospect of success, it is possible to forecast, both in efficiency and cost, the results of the best known methods and works."

Three distinct processes have to be recognised and considered in any well designed scheme of disposal. First, the treatment at the house where the refuse originates; secondly, the ways of collection, transporting and delivering the material at the points of disposal; and thirdly, the various means for its sanitary disposition, whether separately or in the mass. In the work of house collection in England, the usual custom is to mix all the refuse indiscriminately and to have it conveyed to incinerators. But in America, owing to the greater extravagance of the people, there is a greater tendency, or a more hopeful prospect of employing methods, which conserve more of the valuable portions of the garbage. It is estimated that the quantity of combined house rubbish is about two and a half times as much as in European towns, while its value is greater in the same proportion. Here it is not without interest to remark, as throwing an illuminating side light on the habits of a great nation, that the effect of the war on the production of city garbage was to entail a general decrease in the quantity *per capita*, together with a diminution of the value of the recoverable elements. Reports from sixty cities showed that during 1917 the average decrease in the quantity of garbage was from 12 per cent. to 15 per cent. The decrease in food waste was clearly indicated by the reduced quantity of grease. Meats are the chief source of grease in garbage, and data from the reduction works showed that while the decrease in quantity of material treated was 15 per cent., the grease recovered showed a falling off of 30 per cent. as compared with 1916. It is anticipated that the decreased production of grease will continue, since the Americans are cultivating more frugal habits, and so marked is this readjustment of conditions that in some cities changed methods of disposal are likely to be adopted. But for the present the householder is expected to assist in the economical collection of refuse, by sorting the materials roughly. Separate receptacles, or cans to use the American term, have to be provided for ashes, for vegetable garbage and for solid rubbish, as waste paper and discarded trifles. Or the sorting may be effected by the collecting cart removing only certain articles on certain days, and then the same can may be used. But in any case, the can is expected to be thoroughly cleansed, and in some towns to facilitate this cleansing, the collection is effected by removing the full can with its contents and leaving a cleaned and empty can in its place for refilling. The can arrangement is apparently no more satisfactory or less unsightly in America than it is here, and it is admitted that the can may be as great a nuisance as the garbage, or even greater. Theoretically, cleanliness is insisted upon strenuously, and rules printed on cards are widely distributed, a practice that is believed to have a good effect in promoting neatness and efficiency. The size, make, and use of the can are insisted on with great minuteness, but apparently the general aspect of a city's streets, alleys, and yards, where these receptacles are exposed, leaves much to be desired. The general practice is to set the can on the side walk, but this could be avoided, if the attendant with the collecting cart himself brought the can from the house. The latter seems a preferable arrangement, but a more expensive. It is one of the merits of this work that we can learn with some precision the probable cost of introducing alternative plans. Tenders were invited in a town for the collection of refuse under two schedules, one, that the householder should himself set the can out in the curb, the other, that the collector should carry the can from the basement. The lowest tender in the first case was 4·60 dol. per house per annum, and in the second 12 dol. For a town of 100,000 people this difference would amount to about 147,600 dol. per annum. This is a small item, but it is an indication that the total cost of a nation's refuse collection will amount to a formidable sum. In some of the large cities in the United States, municipal collection is not considered satisfactory, and private associations are organised to do the work of collection. In Chicago, there were no less than 130 such associations in 1913, and the annual expenditure of only twelve of these amounted to 166,000 dol. It is important to keep in mind the magnitude of the work involved in removal. It is the most important and costly single element of the entire refuse problem, and one where improvements in equipment and organisation can be most readily made.

In large centres of population, the sanitary engineer is met with another difficulty. As the congested districts spread over larger areas, suitable sites for disposal can be found only at greater and greater distances from the centre of production, and some method for transportation in bulk has to be devised. The position of subsidiary or temporary centres of collection is determined by the limit of economic haul, whether by horse drawn vehicles or mechanical propulsion, and the conveyance from such centres to the point of final disposal constitutes a new problem. Economy may be the main factor in deciding the number and position of such intermediate transfer stations, but proper sanitation requires the provision of devices that will prevent the escape of offensive odours and confine the dust in the wagon during dumping and in transit. In this country, it is true, this further problem of bulk conveyance rarely arises. The one method adopted for the disposal of refuse is incineration, consequently the haul can be short, for incinerators, especially of the high temperature type, can be constructed within the town and the operation of destruction carried on without producing any noticeably ill effects. London is reported to have 14, and Paris 5 incinerators, within the municipal area. Evidently the most suitable size and class of vehicles to be employed, the selection of route, the choice of dumping ground, the effect of seasonal variation on the character of the refuse and other topics, are of the utmost importance to the engineer, but the systematical analysis of information at command for guidance and instruction is slender, and on that account this work which aims at discussing the various experiences in the disposition of municipal refuse should be welcome.

The material being collected on the selected ground the final disposition, whether destruction or utilisation is preferable, has to be decided. To be satisfactory, this disposition must fulfil the requirements of economy and sanitation, or since there is always a loss to be met, the expenditure must be the least that will effect a sanitary disposal of all the waste material. By sanitary disposal is meant the control of the organic decomposition, the prevention of objectionable odours, the recovery of any valuable parts, in which may be included the production of steam for power, and the reduction of the final residue to the smallest quantity and the least offensive condition. Dumping into large bodies of water is a common practice where feasible, and is satisfactory if floating refuse is prevented from stranding on the shore. Dumping on land gives good results for ashes and rubbish, unmixed with garbage, but precautions are needed to prevent fly breeding, and fires on the dumps. The filling up of large depressions and old excavations is to be recommended, as it is possible to secure unobjectionable oxidation of the organic matter in place of putrefaction. Ploughing into soil and burial is better adapted for small towns, and in sandy soils may be attended with happy results.

Each of these methods of disposal is discussed with thoroughness, and the variations that have been found necessary in particular districts afford a number of instructive examples which will interest the expert, but there is one other natural method of riddance that appears to be far better organised and pursued on a larger scale, than has been attempted in Europe. The feeding of swine on garbage has long been practised in an irregular manner, not for the hog's benefit but to get rid of an undesirable commodity. The creation of hog-farms, in which the animals are fed entirely on garbage, the product of house to house collection, is purely an American industry. It has been stimulated by the war and the high price of pork. At present prices, garbage when disposed of by swine feeding is worth from 7 dol. to 8 dol. per ton of house refuse. The vegetable waste must be separately and cleanly collected, and at frequent intervals, and in communities where this is possible and a market is convenient, no other method of disposal shows equal returns. The authors devote very considerable space to this subject, and evidently regard the plan as a valuable adjunct to agriculture. Some notion of the extent of the trade can be gathered from the fact that the most serious drawback in hog feeding has been the difficulty of obtaining reliably tested and standardised serum and virus for inoculation against cholera. This scarcity does not seem to be due to the specially fed swine being peculiarly sensitive to cholera, but simply that the great increase in breeding has exhausted the supply of virus. The quality of the pork is not considered inferior to that of the so-called "dairy fed," but the yield in meat is perhaps 10 per cent. less.

Only the briefest mention can be made of two other important sections, destruction of refuse by cremation and the reduction of garbage. The mixed refuse incinerators, which have obtained so largely in Europe, mainly because of the ease of collection, are increasing in popularity in America, for experience shows that with proper design and operation the method is sanitary and efficient. Useful rules, founded on large practice, are given for the control of the incinerator, and emphasis is rightly laid on the necessity of keeping the temperature of the developed heat high enough at its minimum, to destroy effectually all organic solid and gaseous matter before reaching the chimney. This implies the use of forced draft, and in low temperature furnaces, additional fuel. It seems to be a common practice in the States to fail to raise the temperature sufficiently high to prevent the escape of offensive odours, though it is admitted that the percentage of unburnt coal contained in domestic refuse is greater than in this country. Steam, too, is not utilised from the waste heat to the same extent it is with us, and the conclusion is drawn that it would be wise for the local authorities to give more attention to the production of steam, chiefly to reduce cost, rather than to make a profit.

On the other hand, the reduction processes for the treatment of garbage, or the recovery of the valuable constituents by the application of heat and mechanical agitation, has advanced much further. This is attributed to the possession of a garbage rich in recoverable elements, traceable to the greater wastefulness of the American people, as well as to the general adoption of the separate collection system. The schemes for recovery are well explained and seem inviting, but we cannot think that the methods will come into favour. For one reason our towns generally are too small to warrant the adoption of such expensive schemes. Small plants are uneconomical. In Chicago where 3,500,000 dol. are provided for the full equipment of a refuse scheme, 85,000 dol. are earmarked for the expenses of a technical staff. This is a grandiose style which we may admire, but cannot imitate. Moreover, it

is admitted that about one half of the reduction works built in America have been abandoned, because of the offensive gases and vapours generated and of the dangers of fire and explosion.

The authors do not recommend any practice, they have written and analysed the information for our guidance, and to enable all to grasp the results of experience, to avoid the errors of the past and to profit by what has been proved. It was a work that was needed, and they will earn the thanks of many who hitherto have not known where to find so authoritative a collection of facts, sifted and digested by practical and varied knowledge.

Engineering Steels. An Exposition of the Properties of Steel for Engineers and Users to Secure Economy in Working and Efficiency of Results. By LESLIE AITCHISON, D.Met., B.Sc, M.I.A.E. London: Macdonald and Evans. [Price 25*s.* net.]

AT the present day engineers are searching for materials of construction which will give a higher duty per unit of weight than they can obtain by the use of mild steel or other materials at present in use, and, having stated the problem to metallurgists, they have been not a little overwhelmed by the response. They have now so many alternatives to choose from that the difficulty of choosing is almost as perplexing as the original trouble, and, in addition, a voluminous literature has stated for their guidance and for those in doubt the simplicity of the principles involved in the solution. Metallurgical work has expanded rapidly and has produced its own type of report, which often presumes a knowledge of its development and descriptive terms that few men in other branches of technics can lay claim to, and neglect is the inevitable result. No one will deny the need at this stage, therefore, for a book which will explain to engineers in the terms of their own mode of thought the advances which have been produced in steels of high strength and toughness and the differentiation in the properties of the many classes now manufactured, and this book undoubtedly makes an attempt to fill this need. Unfortunately, however, it is not altogether successful. The author's training has evidently been wholly metallurgical and his outlook is narrow. Tensile tests, shock tests, hardness tests are not the confines within which the engineer has his being, and yet the whole subject is discussed from a restricted point of view, in which such laboratory tests fill a very large portion of the field of vision, and any reference to the result of general engineering experience in special steels will be looked for in vain. Machining properties, for instance, are covered by a general statement of about four lines. It is a book written on the general properties of steel and its heat treatment from the standpoint of the metallurgist.

The first chapter opens with a description of the processes used to manufacture steel, which are outlined briefly so far as the principal facts are concerned, but it is to be regretted that in some cases a certain looseness of diction leads to confusion and wrong impressions. A steel containing 0·12 per cent. of silicon, for instance, could hardly be called "a typical basic steel." The casting and working of steel are given full treatment and show that the author has made a close study of Brearley's views, which he expounds without hesitation.

There follows a section on the heat treatment of steel, which is described very fully, and is a well compiled chapter written with understanding from an obviously wide experience. There are many engineers who, having only a slight acquaintance with heat treatment work, find it difficult to understand why nickel steel and other alloy steels should require to be treated so differently from plain carbon steels, and why quenching followed by reheating should be a better way of obtaining the strength required than a simple annealing. To the metallurgist the answer is so obvious that he often has the greatest difficulty in explaining it, and he loses sympathy with the questioner. Mr. Aitchison has taken pains, however, to answer even the obvious questions, and we know of no better introduction to the subject of heat treatment than the chapter which he has written for this book.

Again, there are no convenient sources where one can obtain the physical properties of carbon steels after varying thermal treatment, but in the chapter headed "Plain Carbon Steels" will be found a most useful compilation of this information relating to commercial steels, and not merely to such steels of special purity as are generally used for the purposes of research. The strength after tempering at varying temperatures, the effect of mass and of manganese are dealt with fully, and the complete results are set out in a series of tables and curves which will be of much practical service. The section on alloy steels contains a fair amount of information, but it is neither so complete nor so informative as the preceding chapter. Too much space is given to air hardening nickel chrome steel in proportion to others, for, although interesting from a metallurgical standpoint, it is seldom used except for the special purpose of certain motor car gears and other more widely-used steels are not mentioned by the author.

Case-hardening steels are considered at some length, without the treatment of the subject being in any way different from similar chapters published in other textbooks, and cold-worked steels and tool steels are treated in such a sketchy manner that they might well have been omitted without detracting from the value the book possesses. Considered from the engineer's standpoint, we find this book disappointing, but it will undoubtedly be useful for the metallurgical information which it contains.

BOOKS RECEIVED.

The Cochran Book of Oil-Firing. Part I. *Oil Fuel at Sea.* Part II. *Oil Fuel on Land.* By W. K. WILSON, B.Sc., Wh.Ex. Annan: Cochran and Co., Annan, Limited. [Price 4*s.* 6*d.* net.]

Mex Fuel Oil. Second edition. London: Anglo-Mexican Petroleum Company, Limited. [Price 10*s.* 6*d.* net.]

"The Royal Mail" War Book; Being an Account of the Operations of the Ships of the Royal Mail Steam Packet Company, 1914–19. By H. W. LESLIE. London: William Heinemann. [Price 10*s.* 6*d.* net.]

Centrifugal Pumps. By J. W. CAMERON, A.M.I.Mech.E. London: Scott, Greenwood and Son. [Price 12*s.* 6*d.* net.]

Theoretical Mechanics. An Introductory Treatise on the Principles of Dynamics with Applications and Numerous Examples. By A. E. H. LOVE, M.A., D.Sc., F.R.S. Third edition. Cambridge: The University Press. [Price 30*s.* net.]

Der 1,000 P.S. Flugmotor. Von Dr. Ing. EDMUND RUMPLER. Munchen und Berlin: R. Oldenbourg. [Price 50 marks.]

United States Department of Commerce. Bureau of Foreign and Domestic Commerce. Monthly Summary of Foreign Commerce of the United States, January, 1921. Washington: Government Printing Office. [Price 10 cents.]

Memorandum on Carbon Monoxide Poisoning in Factories. London: His Majesty's Stationery Office. [Price 3*d.* net.]

Department of Overseas Trade. Report on the Trade Industry and Finance of Morocco. May, 1921. London: H.M. Stationery Office. [Price 2*s.* net.]

Automatic Telephone Systems. Vol. I. *Circuits and Apparatus as Used in the Public Services.* By WILLIAM AITKEN, M.I.E.E., A.Am.I.E.E. London: Benn Brothers, Limited. [Price 25*s.* net.]

Two Centuries of Shipbuilding by the Scotts at Greenock. Second and revised edition. London: Offices of ENGINEERING.

The Health of the Industrial Worker. By EDGAR L. COLLIS, B.Ch., M.A., M.D., M.R.C.P., and Major GREENWOOD, M.R.C.P., M.R.C.S. *Containing a Chapter on Reclamation of the Disabled.* By ARTHUR J. COLLIS, M.A., M.D., M.R.P.S. London: J. and A. Churchill. [Price 30*s.* net.]

Memoria que Manifiesta El Estado y Progreso de las obras de Mejora de la Ria y Puerto de Bilbao y Relación de Ingresos y gastos, 1920. Bilbao: Imprenta y Litografia de Ematerio Verdes y Achirica.

United States Geological Survey. Mineral Resources of the United States. I: 30. *Tungsten in* 1918. By FRANK L. HESS. II: 16. *Salt, Bromine and Calcium Chloride in* 1919. By HERBERT INSLEY. II: 19. *Mica in* 1919. By HERBERT INSLEY. Bulletin No. 704. *Geology of the Igneous Rocks of Essex County, Massachusetts.* By CHARLES H. CLAPP. [Price 30 cents.] Professional Paper No. 128—E. *American Species of Operculina and Heterostyina and their Faunal Relations, and a New Species of Orthophragauvia from Louisiana.* Papers by JOSEPH A. CUSHMAN. Washington: Government Printing Office.

ELECTRIC MACHINERY FOR SOUTH AFRICA.—The Rand Water Board invites tenders for the supply, delivery and erection at the Board's main pumping station, Vereeniging, of two steam-driven electrical generating sets of 350 kw. capacity, each complete with switchboards and all accessories. Tenders will be received at the offices of the Secretary of the Rand Water Board, P.O. Box 1703, Johannesburg, up to 12 noon on November 7. Further information can be obtained by United Kingdom firms interested on application to the Enquiry Room, Department of Overseas Trade, 35, Old Queen-street, Westminster, S.W.1.

THE LATE SIR FRANCIS W. T. BRAIN.

WE regret to have to place on record the death of Sir Francis William Thomas Brain, of Huntworth, Stoke Bishop, who was closely identified with the mining and other industries of the Forest of Dean, and did pioneer work in connection with the application of electricity and of blasting to mining. Born on October 28, 1855, the son of the late Mr. Cornelius Brain, of Ruardean, he received his general education by private tuition and at the grammar school at Monmouth from 1864 to 1870 and his practical training under Mr. W. Blanch Brain at the Trafalgar Colliery at Drybrook from 1872 to 1875. In the latter year he became Assistant Manager of the Iron Mines of the Drybrook Iron Company, Limited, and subsequently Assistant Manager at the Trafalgar Collieries, and soon after General Manager of the Trafalgar Collieries, of which he was in entire charge for ten years. The firm was known as the Trafalgar Colliery Company, Limited.

In January, 1883, he constructed, underground, at these collieries a small electric pumping plant, which was claimed to have been the first application of electricity ever made underground. This was followed shortly afterwards by a much larger installation, viz., a pump with a 300 ft. head, which is still working. In 1885 he perfected an electric fuse to fire explosives in gaseous mines. This, the Brain's Electric Fuse or the Cinderford Fuse, is well known in connection with blasting in mines.

In 1891 Sir Francis became Agent and Managing Director for the Trafalgar Colliery Company, Limited. In 1903 he put in at Trafalgar Colliery a complete system of main and tail haulage driven by electricity. This installation excited great interest at the time, and was visited by many engineers of this and other countries. He also, some years later, constructed an endless rope haulage plant, worked by electricity. Throughout the negotiations connected with the National coal strike in 1912 he acted, at the request of the coal owners, as their chairman. He gave evidence before several Royal Commissions and Departmental Committees. He was appointed by the Home Office a member of two departmental committees. He was a member of the Mines Examination Board, and was also appointed to serve on the Advisory Committee of the Government control of coal mines.

He became a member of the Institution of Civil Engineers in 1912, having been an associate member from 1891. In 1894 he was President of the National Association of Colliery Managers. He was for many years a member of the Institute of Mining Engineers, and was also at one time President of the Mining Association of Great Britain. He was a Fellow of the Surveyors Institution. Sir Francis contributed numerous papers to the publications of mining and other associations, and at the British Association meeting at Bath in 1886 he read a paper on electricity as applied to mining. He was created a Knight in 1913.

For some years past Sir Francis' health has not been robust; even a long sea voyage failed to improve it, but he continued to take an interest in public affairs. His death on August 31 was due to the after effects of an operation for appendicitis greatly to the regret of his many friends in Bristol.

PATENTS IN THE UNITED STATES.—We read in *The Iron Trade Review*, Cleveland, Ohio, that in the first half of 1921, the Patent Office at Washington received 45,005 applications for patents, compared with 42,607 in the first half of 1920, 37,143 in the first half of 1919, and 31,568 in the first half of 1918. An official statement says: "In spite of the industrial depression, the amount of business presented to the patent office in every branch has constantly increased since the year 1918, and has increased by leaps and bounds. The demands upon the patent office are beyond any previous figures in its history, and there is no recession in sight. These demands are far in excess of the capacity of its limited and practically stationary force."

"THE SCOTTISH TRADE COURIER."—This is the title of a book printed in English, French, Spanish and Italian, issued by the Glasgow and West of Scotland Guardian Society, Limited, 30, George Square, Glasgow, and covering all classes of industries in Scotland. The object of the publication is to further the trade of those industries with all countries of the world. Reference to every trade and to the manufacturers of every specialty is facilitated by alphabetical indexes of trade and firms in each language. The book has three main divisions, engineering, textile and miscellaneous. It is admirably got up, and its wide distribution should greatly foster foreign trade with Scotch manufacturers. Copies of the book are sent to British, foreign and Colonial buyers; British, Colonial and foreign chambers of commerce, Government trade departments in the Dominions and British consuls and consular agents. The Society publishing it states that the insurance of trade credits is also a branch of its activities; policies are issued covering commercial debts, enabling the exporter to increase his volume of trade without incurring greater capital responsibilities.

EXPERIMENTS ON THE MECHANICAL PROPERTIES OF SCOTS PINE.*

By Professor ALEX R. HORNE, B.Sc.

THE purpose of this Paper is to record the results of a series of experiments which were carried out by the author in the engineering laboratory of Robert Gordon's Technical College, in collaboration with Mr. Alexander Cruickshank, head of the Building Trades Department there, on the properties of Scots pine grown in the northern forests of Scotland.

By the kindness of the Timber Supplies Department of the Board of Trade, three average trees were supplied from each of the following forests:—

Fetternear, Aberdeenshire.
Nethy Bridge, Banffshire.
Ballindalloch, Banffshire.
Forres, Morayshire.
Orton, Morayshire.
Glenmore, Invernessshire.

The diameters of the trees at the butt varied from 20 in. to 13 in. Records were made of the nature of the soil, exposure, elevation, and whether the forest was natural or planted. These particulars are not given here, in view of the fact that an analysis of approximately 300 tests made failed to disclose the influence of any of these factors upon the results obtained.

All the trees were approximately 100 years old.

Each tree was cut into three logs, 7 ft. long—the butt, middle and top cuts—while a 2-ft. cut was taken from between the butt and middle cuts to provide specimens for tests in compression and shear. These latter tests have not yet been made.

The 7-ft. logs were very carefully sawn lengthwise into cross-breaking specimens measuring 5½ in. by 2½ in. in section, at the works of Messrs. John Fleming and Co., Aberdeen. Immediately after cutting, the specimens were weighed, marked, and stacked on edge with an air space of 1 in. between, horizontally and vertically, in a drying shed. This shed was roofed, but was open on the sides to allow of a free current of air to pass through.

All the trees, with the exception of those from Orton, were felled between March 10 and March 23, 1918; those from Orton being brought down on April 26, 1918. The specimens were removed from the drying shed to the laboratory on August 10 following. Thus the period of seasoning in the open was approximately four months, except in the case of the trees from Orton, which was about ten weeks.

On arrival at the laboratory, the specimens were re-weighed in order that the loss of moisture during seasoning in the open might be determined. They were then stacked in the same manner as in the shed to await the cross-breaking and other tests.

The average period of seasoning in the laboratory of all but the Orton specimens, was approximately five months. The Orton specimens remained ten months before breaking. As a result of this longer period, the Orton specimens contained less moisture than did the others at the time of testing.

The cross-breaking tests were carried out in a 50,000-lb. compound-lever testing machine, which had been specially adapted for the purpose. The specimen was suspended from the lever by two shackles placed at 24-in. centres, these being hung from a cross-beam pivoted upon the lever. The load was applied by two similar shackles at 6-ft. centres, attached to a girder which was fixed to the moving head of the machine. In this way two-point loading, which is to be preferred to central loading, was obtained. The span was, in every case, 6 ft., and the load was applied at two points 2 ft. from the supports. The arrangement of the testing machine is well shown in Figs. 2 and 3, on page 388.

In order to allow for any tendency to unsymmetrical loading which would arise from inequalities in the material along the length of the specimen, the beam carrying the upper shackles was not rigidly fixed in a direction parallel to the specimen, but was pivoted to the lever of the machine at the centre of its length. The loading pins in the shackles were free to turn in the checks, and had blocks of hardwood fixed to them which bore against the specimen. These blocks were thus free to rotate as the deflection of the specimen proceeded, and so obviated the tendency of the block to destroy the fibres of the beam. The hardwood blocks proved most satisfactory, and made practically no indentation in the specimens.

A deflection meter of the dial type was designed for the tests. It was supported from the ends of the specimen and was thus free from the influence of deformations of the straining gear. It read to thousandths of an inch and was calibrated before the tests were begun and also during their progress. The arrangement of the machine is shown in the illustrations.

Preliminary experiments disclosed that the curve of deflection against load was sensibly straight up to a load of 4,000 lb. It was decided to determine the modulus of elasticity between loads of 500 and 3,500 lb. The stress corresponding to the latter load is approximately 4,000 lb. per square inch. Except in the case of a few specimens, readings of deflection were also taken at loads of 1,000 lb., 2,000 lb., 3,000 lb. and 4,000 lb., and frequently at 5,000 lb. and 6,000 lb.

A record sheet was kept for each specimen. In addition to reference numbers, records were made of:—

(*a*) The weights of the specimen at cutting, after air-drying and at breaking.
(*b*) The length, breadth and depth of the specimen.
(*c*) The breaking load.
(*d*) The nature, and immediate cause of fracture.
(*e*) The deflections corresponding to the loads.
(*f*) The direction of the annular rings.
(*g*) The position of knots or other defects.

(*f*) and (*g*) were noted upon an isometric sketch of the specimen.

Immediately after the specimen was broken it was cross-cut into three equal parts and a section, about ½ in. thick, was taken from each end of the central portion, from which the moisture content at the time of breaking was subsequently determined by maintaining the sections at a temperature between 216 deg. F. and 220 deg. F. in an air bath, for five hours. The average for the two sections was taken in subsequent calculations. These sections also served for the determination of the percentages of sap and heartwood.

The moisture content at the time of breaking was found for about 40 per cent. of the specimens broken. In the case of one tree, all the specimens were tested for moisture content. The uniformity of the results obtained appeared to justify average values being taken where all of the specimens from one log were not tested for moisture.

From this information, together with the weights of the specimens (*a*) immediately after cutting, (*b*) after air-drying in the open, and (*c*) at the time of breaking, it was possible to determine the moisture content at the time of felling and after seasoning in the open, and in this way to deduce useful information regarding the effect

TABLE I.—SPECIMEN OF RECORD. FETTERNEAR, TREE B. BUTT.

Serial No.	Reference No.	Dimensions. Length. Ins.	Depth. Ins.	Breadth. Ins.	Volume. Cub. Ft.	Percentage of Moisture as Broken.	Weight Lb.) After Cutting.	After Air-Drying.	As Broken.	Dry.	Percentage of Moisture Calculated on Dry-Weight. At Cutting.	After Air-Drying.	Density. Lb. Per Cub. Ft. As Broken.	Dry.	Breaking Load. Lb.	Modulus of Section.	Breaking Stress. Lb. per Sq. In.	Deflection between 500 and 3,500 Lb. Ins.	Moment of Inertia.	Modulus of Elasticity in Thousand Lb. per Sq. In.	Percentage of Sapwood.	Percentage of Heartwood.	Details of Grain.	Remarks on Fracture.
31	17 A	84½	5·20	2·52	0·646	15·7	37·4	26·95	26·3	22·2	68	21·5	40·7	34·4	9,250	11·35	9,780	0·348	29·51	1,936	41	59		Normal fracture in tension.
32	B	84½	5·21	2·54	0·645	15·3	25·3	23·15	22·75	19·3	31	20·0	35·3	29·9	4,840	11·49	5,050	0·601	29·93	1,106	0	100		Break along heart-shake.
33	C	84½	5·21	2·60	0·659	17·1	36·25	29·25	28·85	23·9	52	22·2	43·7	36·4	9,540	11·76	9,740	0·355	30·63	1,828	23	77		Normal fracture in tension, preceded by slight compression.
34	D	84½	5·18	2·59	0·655	15·8	31·95	26·9	26·5	22·3	43	20·7	40·5	34·0	8,230	11·58	8,530	0·385	29·99	1,817	9	91		Normal fracture in tension, with failure in compression.
35	E	84½	5·24	2·53	0·648	16·5	39·05	28·25	27·7	23·15	69	22·1	42·8	35·8	8,200	11·57	8,510	0·437	30·31	1,501	48	52		Normal fracture in tension, with slight horizontal shear.
36	F	84½	5·22	2·52	0·644	15·3	40·8	25·55	25·25	21·4	91	19·4	39·2	33·2	8,800	11·44	9,225	0·372	29·85	1,790	61	39		Normal failure in tension.
37	G	84	5·15	2·59	0·648	16·0	44·6	23·35	23·0	19·3	131	21·0	35·5	29·8	9,350	11·44	9,800	Not taken			93	7		Normal failure in tension.

TABLE II.—SUMMARY OF RESULTS.

Forest.	Trees.	Weight of Specimen. Lb. After cutting	After Air-Drying.	As Broken.	Dry.	Moisture Per Cent. Calculated on Dry Specimen. After Cutting.	After Air-Drying.	As Broken.	Density Lb. Per Cub. Ft. As Broken.	Dry.	Maximum Stress. Lb. per Sq. In. Normal Specimens.	All Specimens.	Modulus of Elasticity in Thousand Lb. per Sq. In. Normal Specimens.	All Specimens.
Glenmore	Average of the Top, Middle and Butt specimen of three trees.	—	23·2	22·8	19·4	—	19·25	15·5	35·15	29·65	8,120 (29)	7,380 (44)	1,236 (28)	1,196 (40)
Fetternear		—	22·0	21·7	18·3	—	20·5	15·7	32·8	27·2	6,050 (35)	7,420 (48)	1,374 (31)	1,315 (41)
Nethy Bridge		—	23·3	22·2	19·4	—	20·25	15·5	35·8	30·3	7,990 (12)	6,775 (27)	1,221 (12)	1,177 (27)
Altyre-Forres		—	22·85	21·75	19·0	—	20·5	15·75	35·25	29·7	8,830 (31)	7,690 (54)	1,374 (38)	1,384 (53)
Ballindalloch		—	21·65	21·35	18·0	—	20·6	15·76	33·1	27·8	7,170 (38)	6,690 (51)	1,305 (37)	1,267 (47)
Orton		—	25·55	24·8	21·6	—	18·25	12·83	37·7	33·55	9,070 (34)	8,080 (48)	1,671 (34)	1,581 (48)

NOTE.—The breaking stresses and moduli of elasticity have been tabulated under two heads: normal and all specimens; the figures within the brackets give the numbers of specimens falling under each.

* Paper read before Section G. of the British Association, at Edinburgh, September 8, 1921.

of seasoning, both in the shed and in the laboratory. The dry density of each specimen was also calculated from the weight and moisture content at the time of breaking.

A record sheet was prepared for each portion (butt, middle or top cut) of each tree, of which a specimen is given in Table I.

A summary of the results obtained from the trees from the several forests is given in Table II.

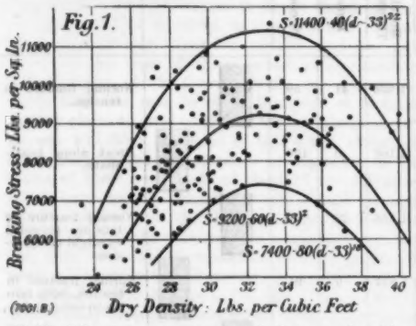
The various causes or modes of failure are classified in Table III.

Table III.

Cause, or Mode, of Failure.	Normal.	Abnormal.	Total.
Tension side only	152	—	152
,, with compression ..	9	—	9
,, with shear	3	2	5
Compression only	1	—	1
Horizontal shear only	1	—	1
Shear along heartshake	—	2	2
Tension, hastened by grain running out at knot	5	24	29
Fracture hastened by knots otherwise than by tension ..	7	20	27
Tension, with suggestion of horizontal shear	1	1	2
Cross-breaking through knots ..	—	44	44
Total	179	93	272

The specimens were divided into two classes—normal and abnormal—by inspection before breaking. Normal specimens are those which appeared to contain no serious flaws, and were such as might be selected for first class constructional work; while specimens which disclosed large knots, shakes, etc., were classed as abnormal.

Fig. 1.



(7001 B.)

Table IV. gives a summary of the cross-breaking strengths of the specimens. It will be observed that, of the 272 specimens tested, 179, or 66 per cent., were classed as normal. This gives a fair representation of the quality of this class of wood, and suggests the necessity for improved silviculture in order to procure a larger percentage of clean timber. The presence of knots has been the chief cause of the unpopularity of home-grown pine and other common woods.

Table IV.

	Normal Specimens.		All Specimens.		No. of Normal Specimens to All Specimens, Per Cent.
	No.	Stress.	No.	Stress.	
Maximum of all ..	—	12,600	—	12,600	—
Minimum of all ..	—	5,075	—	2,870	—
Average of three trees.					
Orton*	34	9,070	48	8,080	71·0
Forres	31	8,830	54	7,690	57·5
Glenmore	29	8,120	44	7,380	66·0
Fetternear	35	8,050	48	7,420	73·0
Nethy Bridge ..	12	7,990	27	6,770	44·5
Ballindalloch	38	7,170	51	6,690	74·5
	179		272		
Average of all, lb. per square inch ..	—	8,200	—	7,380	—
Average of all, cwts. per square inch ..	—	73·2	—	65·8	—

* It is to be remembered that the specimens from Orton were, at the time of breaking, drier than the others.

Table V.—*Values of Modulus of Elasticity.*

	Elasticity in Thousand Lb. per Square Inch.		Breaking Stress in Lb. per Sq. In.
	Normal Specimens.	All Specimens.	Normal Specimens.
Maximum of all	2,085	2,085	—
Minimum of all	741	741	—
Average of three trees.			
Orton	1,671	1,581	9,070
Forres	1,374	1,384	8,830
Fetternear	1,374	1,315	8,050
Ballindalloch	1,305	1,267	7,170
Glenmore	1,236	1,196	8,120
Nethy Bridge	1,221	1,177	7,990

EXPERIMENTS ON SCOTS PINE.

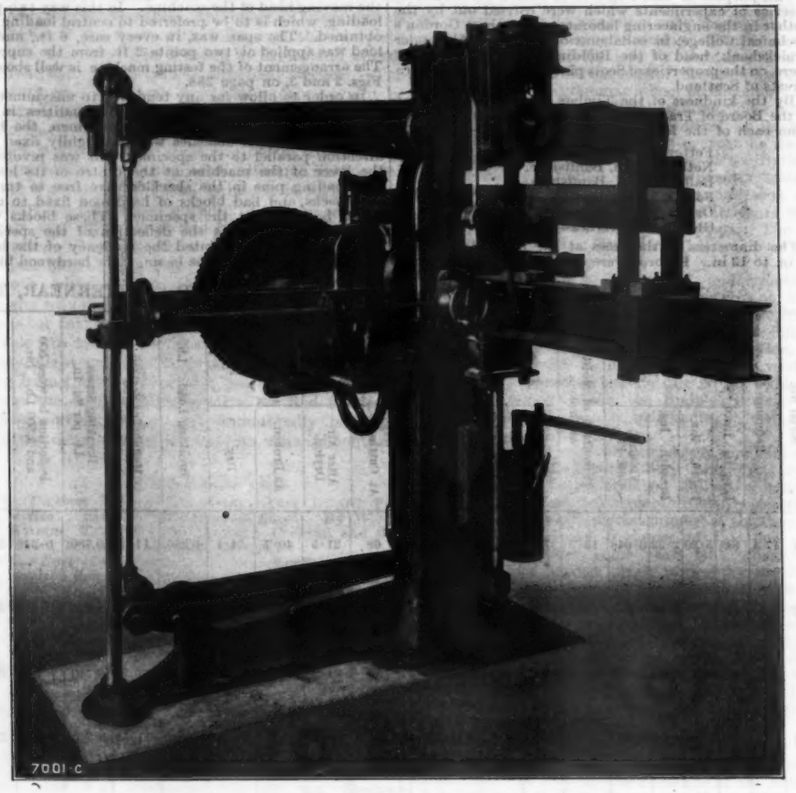


Fig. 2.

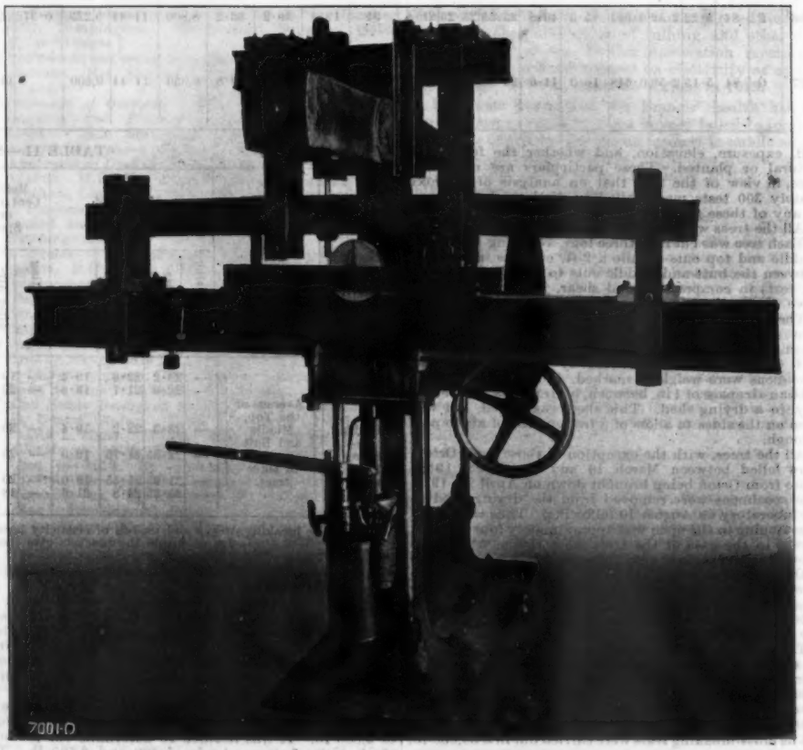


Fig. 3.

The values of the modulus of elasticity, in thousands of pounds per square inch, are given in Table V.

By plotting, for normal specimens, the breaking stress against the dry density, the interesting fact that there is a "best dry density" was disclosed. The plottings are shown in Fig. 1.

The best dry density is in the region of 33 lb. per cubic foot. Beyond this value the strength appears to diminish. Many of the specimens whose dry density exceeded 33 lb. per cubic foot, by their flaky and short texture and by the dust given off at fracture, suggested over-maturity and led to the conclusion that better results would have been obtained had these trees been felled at an earlier age.

Referring to the mean curve and the two envelopes in Fig. 1,

if S denotes the breaking stress, in lbs. per square inch,

d denotes the dry density, in lbs. per cubic foot.

then for the mean curve,

$$S = 9{,}200 - 60\,(d \sim 33)^2,$$

while the upper and lower envelopes are given by

$$S = 11{,}400 - 40\,(d \sim 33)^{2\cdot2}$$

and $$S = 7{,}400 - 80\,(d \sim 33)^{1\cdot8}.$$

As was to be expected, the strength of the timber was found to increase with increase in the modulus of elasticity. An examination of the notes relating to the fractures of certain specimens indicates that, while the specimens had been characterized as normal, the breaking load had fallen below the true normal value by reason of knots near to the tension edge having caused the grain to run out, but such defect does not affect the modulus of elasticity to the same extent.

If S denotes the breaking stress, in lb. per square inch, and E denotes the modulus of elasticity, in lb. per square inch, the mean line in a graph of breaking stress and modulus of elasticity gives:

$$E = 170\,S,$$

while the upper and lower envelopes represent:

$$E = 215\,S$$

and $E = 130\,S$ respectively.

Substituting the above value of S in the appropriate equations, the relation between the modulus of elasticity and the dry density, for the mean value, is given by:

$$E = 170\,S = 156{,}400 - 10{,}200\,(d \sim 33)^2,$$

and, for the upper and lower envelopes, by

$$E = 215\,S = 2{,}451{,}000 - 8{,}600\,(d \sim 33)^{2\cdot2}$$

and $$E = 130\,S = 962{,}000 - 10{,}400\,(d \sim 33)^{1\cdot8}.$$

In the majority of instances curves of deflection against breaking load, which latter is directly proportional to the maximum stress if the slight variations in the dimensions of the sections are neglected, have the slight upward curvature generally characteristic of timber; while in some, and particularly in the specimens from Glenmore, the lines are straight, up to a load of 5,000 lb., which corresponds to a stress of about 5,250 lb. per square inch.

When the percentage of moisture, at the time of felling is plotted, for each tree, against the fraction of sapwood it is found that the points lie upon a straight line. If M is the percentage of moisture and s is the fraction which the sapwood bears to the whole section, the relation can be expressed by

$$M = a + b\,.\,s$$

where a and b are constants.

When the section is entirely sapwood, $s = 1$, and $M = a + b$; while, when there is no sapwood, $s = 0$, and $M = a$.

The average for the 18 trees tested gave

$$M = 27 + 103\,s$$

which suggests that, for spring-felled timber of the class here considered, the heartwood contains 27 per cent. of moisture, while the sapwood contains 130 per cent.

It is easy to show that the above linear relation between percentage of moisture and fraction of sapwood suggests that the moisture is uniformly distributed over the heartwood and the sapwood respectively.

Notwithstanding the fact that many of the specimens upon which the foregoing tests were carried out were stored for nearly a year after felling, no case of blueing occurred, though a number of specimens which were placed in the open immediately after air-drying, give evidence of the development of blueing.

It is generally understood that the blueing of Scots pine is caused by a fungus (*Ceratostoma piliferum*) with which the tree has been infected, and there is reason to believe that the rate of propagation of these fungi, and the extent of blueing consequent therefrom, is more rapid in cases where the timber has not been air-dried under conditions which protect it from the direct action of the weather, than when the timber is exposed to the weather only after air-drying has been resorted to.

The author is of opinion that, if the moisture content of the timber is reduced by air-drying under protection from the weather, no appreciable blueing will occur, even if the timber is subsequently exposed to the weather for a short period, as, for example, during the construction of buildings.

Conclusions.

The conclusions which may be arrived at from the investigations described can be summarized briefly as under:—

(1) The cross-breaking strength and the elasticity of the timber reach a maximum when the dry density is in the region of 33 lbs. per cubic foot.

(2) The cross-breaking strength is proportional to the modulus of elasticity.

(3) The cross-breaking strength appears to bear no definite relation to the inclination of the annular rings to the neutral axis of the beam, to the closeness of the annular rings, or to the distance from the butt of the portion of the tree from which the specimen has been cut.

(4) The cross-breaking fibre stress, for selected or "normal" specimens, averages 8,200 lb. per square inch, and for all specimens, 7,380 lb. per square inch. Allowing a safe fibre stress of 9 cwt. per square inch, these figures correspond to factors of safety of 8·1 and 7·3 respectively. The factor of safety in the case of the average specimen from the weakest tree, based on the above-mentioned safe fibre stress, is 7·1. The cross-breaking strength of Scots pine, therefore, compares very favourably with that of foreign timber of the same class.

(5) After air-drying for a period of four months, the moisture content of both heart and sapwood is in the region of 20 per cent. Further seasoning, under protection from the weather for a period of five months, reduces the moisture content to 15 per cent.

(6) If ordinary precautions are taken to protect the timber from the direct action of the weather during seasoning, blueing will not occur unless the material is subsequently exposed, for a considerable period, to rain.

The author desires to acknowledge indebtedness to the Timber Supplies Department (Scotland), and, in particular, to Sir John Stirling Maxwell, Assistant Controller (Scotland) of the Department, for the sympathetic interest which he has shown in connection with this research; to Mr. Peter Leslie, M.A., B.Sc., Lecturer in Forestry, Aberdeen University, for having arranged for the supply of specimens, and to Sir John Fleming, for his kindness in having undertaken the cutting and seasoning of the timber. He also wishes to express his thanks to the Council of the Institution of Civil Engineers for permission to make use of the information contained in his paper on "Strength and Other Properties of Scots Pine," which has been published as a selected paper in the proceedings of that Institution.

THE INFLUENCE OF THE WIDTH OF THE SPECIMEN UPON THE RESULTS OF TENSILE TESTS OF MILD STEEL AND ROLLED COPPER.*

By T. Hudson Beare, B.A., B.Sc., M.Inst.C.E., F.R.S.E., and William Gordon, B.Sc., A.M.I.Mech.E., F.R.S.E.

1. *Introduction.*—It is well known that the strength and the ductility of a metal, as determined in the tensile test, depend not only upon the physical properties of the metal, but also upon the form and dimensions of the test-bar. For example, abrupt variations of section, resulting in virtual shortening of the specimen, raise the apparent strength and lower the apparent ductility of the metal under test.

Again, owing to the phenomenon of contraction at rupture in ductile metals, the apparent ductility diminishes with increase of gauge-length. The extensions of two test-bars of the same linear sectional dimensions are, therefore, not comparable unless measured on the same gauge length.

The extensions of bars geometrically similar, but differing in dimensions, are comparable only by observing Barba's Law of Similarity—Geometrically similar bodies of the same material, under identical conditions and stress, undergo similar deformations. In practice it is exceedingly inconvenient to prepare all test-bars so that they shall be geometrically similar, but the recommendations of the British Engineering Standards Committee go far towards effecting a successful compromise and establishing a much more rational procedure than had prevailed in the past.

Finally, there is the difficulty of obtaining comparable results from bars of the same sectional form but geometrically dissimilar, and from bars of different sectional form. Within limits, this difficulty may be overcome by using for each bar a gauge-length proportional to the square root of its cross-sectional area. Hence, in general, it would appear that it is the specimen of the metal, and not the metal itself, which is tested. The matter is one of great practical importance, for on the form and proportion of the test-piece may depend the acceptance or rejection of a large quantity of material.

2. *Object of Experiments.*—The main object of the experiments was to determine the nature of the influence of the width of the specimen upon the apparent strength and ductility of the metal under test. To that end, metal of constant thickness was employed in each experiment. The investigations are thus confined to the case of rectangular test-bars; but, as the majority of tests made in steel works are carried out on flats, the question is one of more than purely scientific interest.

The research, so far as this paper is concerned, comprises three distinct investigations. In the first place, a preliminary investigation was made into the effects of varying the width of specimens cut from ¾-in. mild steel plate which was obtained locally. The results of this inquiry are dealt with elsewhere,† but, for comparative purposes, some of them are recorded here. Thereafter, a somewhat similar, but much more careful, investigation was carried out on specimens cut from ¾-in. mild steel plate which was specially made for experimental purposes, but which, unfortunately, was over-annealed during heat treatment. The greatest width of bar taken by the 100-ton testing machine in the engineering laboratory of the University of Edinburgh is 4 in.; so that with this thickness of plate, the ratio of width to thickness could be increased to nominally 32 : 1 as compared with 16 : 1 in the previous work. To determine whether the results obtained in the case of mild steel were peculiar to that metal or common to other ductile metals which fail with marked local contraction, a third investigation, on lines similar to those adopted immediately above, was conducted on test-pieces cut from ¾-in. copper plate also obtained locally and of unknown origin. The results of more practical interest derived from these three sets of experiments are set forth below.

3. *Earlier Investigations.*—The earliest record of experimental work on the subject appears to be that of Barba,‡ who discovered that the strength was not appreciably affected by the width of the specimen, but that the ductility, as measured by the percentage of elongation on gauge-lengths of 50 mm. and 100 mm., showed considerable variation. Experiments made on test-bars 10, 20, 30 . . . 80 mm. wide, cut from a 10 mm. mild-steel plate, gave a maximum value of extension for the bar of width equal to six thicknesses—a result for which Barba himself could not satisfactorily account. Later, Appleby,† using a hard grade of Bessemer steel, failed to find the maximum. His results "seem to show that after a ratio of five or six has been reached in hard steel, there is still a tendency to increase in the extension." The highest ratio of width to thickness employed in his experiments was, like that of Barba, eight.

The extensions obtained by Unwin‡ in his classical tests of ship and boiler plates frequently show ill-defined maxima which vary in position as regards the ratio of width to thickness. The elongation equation, $e = \frac{c\sqrt{A}}{L} + b$, derived independently by Barba, Martens and Unwin, obviously indicates no maximum; and experiment shows that it is satisfied only in the case of bars of compact section, such as circular, square, and rectangular of width not greater than about four thicknesses.

Modern British writers on the strength of materials seldom mention Barba's maximum; and Continental authorities, such as Wèvé§ and Bach‖, although referring to the critical ratio, offer no comment thereon. The authors have looked into the available work of Denny, Martens, Bach, Rudeloff and others with much profit, but without finding any results obtained from experiments on flats in which the ratio of width to thickness was greater than twelve.

4. *Experimental Details.*—The carbon-content of the ¾ in. steel, as indicated by micro-analysis, lay between 0·12 per cent. and 0·15 per cent., and that of the ¾-in. steel, as stated by the makers, was 0·13 per cent., the quality of the latter being known as "welding boiler." The copper was practically free from arsenic, and micro-analysis revealed the normal structure.

The plates were sawn into bars 18 in. long in the direction of rolling and of the required widths. Three bars of each width were obtained from the ¾-in. plate and four from each of the ¾-in. plates. Bars of a width were clamped together and machined on the edges; and the mill scale on the faces was removed by light grinding on the sandstone. By this procedure a fairly uniform section was obtained. The linear sectional dimensions, averaged for each set of three bars of the thicker steel and for each set of four bars of the thinner steel and the copper, are given in Table I. Each result recorded is accordingly the average obtained from independent tests of three or of four bars as the case may be.

The centre line of each bar was divided, for its entire exposed length of 12 in., into 1-in. lengths in the earlier investigation and into ½-in. lengths in the two later inquiries, a scribing board and steel trammel being used for this purpose. The extension of bars breaking at some distance from the centre of their length could thus be computed as for fracture at that point. Bars which broke near the grips, or which developed two waists before rupture, were rejected and replaced. The utmost care was taken to ensure axial application of the load, and to secure uniformity in the rate of its application; the same straining speed was employed throughout the tests—about 0·12 in. per minute or 1 per cent. per minute on the 12-in. length between the grips.

The load at yielding for both steels was determined quite readily by the steelyard drop; but in the case of the copper recourse was had to autographic diagrams as a check, the drop not being strongly marked. The maximum load likewise was obtained with accuracy. Owing to the rapidity with which such ductile metals draw out in the last phase of the test, it is somewhat difficult to determine by hand-working of the jockey-weight the exact load at which rupture occurs. This difficulty was more marked in the case of the ¾-in. steel than in those of the other metals. The stress calculated from this final load and the minimum cross-sectional area of the broken bar is termed in what follows, the mean breaking stress.

5. *Yield Point, Tenacity and Mean Breaking Stress.*—Table II shows the effect of variation of width of specimen on these properties of the metals.

The yield point remains practically constant over

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* Paper read before Section G of the British Association at Edinburgh, on September 8, 1921.

† Gordon and Gulliver. Trans. Roy. Soc. Edin., 1911–12, vol. xlviii., pages 195–214.

* Barba. Commission des Méthodes d'Essai des Matériaux de Construction. Paris, Rothschild, 1895, vol. iii., sect. A, page 5.

† Appleby. Proc. Inst. C.E., 1893–94, vol. cxviii., page 395.

‡ Unwin. Proc. Inst.C.E., 1903–4, vol. clv., page 170.

§ Wèvé. Elasticité et Résistance des Matériaux. Paris, Béranger, 1909, page 130.

‖ Bach. Elastizität und Festigkeit. Berlin, Springer 6th ed., 1911, page 143.

the entire range of observation in each case, the average value being 18·14 tons per square inch for the ¾-in. steel, 12·82 tons per square inch for the ½-in. steel, and 7·32 tons per square inch for the ¼-in. copper. The width of the test-bar, therefore, appears to have no appreciable influence upon the elastic strength of mild steel or rolled copper. The tenacity, or commercial maximum stress, also appears to be but little affected. In the case of the two steels there is a slight tendency to rise as the width is increased, but this effect is noticeably absent in the case of the copper. The average values are 25·48 tons per square inch for the thicker steel, 22·37 tons per square inch for the thinner steel, and 14·52 tons per square inch for the copper.

The determination of the factors of the mean breaking stress does not admit of great accuracy; but much care was taken to secure results as correct as possible. As mentioned above, the exact determination of the actual load at rupture is in ordinary circumstances a matter of some difficulty. Again, the fractured surface of an initially rectangular section is not a rectangle but has curved sides. These do not always occur symmetrically about the centre of the width, but are usually so with respect to the centre line of the thickness: the ultimate shape is doubtless determined to a considerable extent by the presence of small local defects. The minimum width of each fractured bar was found by averaging four readings, and the mean thickness by averaging 12 readings, six from each portion. The values of the mean breaking stress for the ½-in. steel vary considerably; but those for the ¼-in. steel and the copper are much more satisfactory. This property, although of not much use to the engineer, furnishes information regarding the true maximum stress sustained by the material. The average values for the three series of tests are 49·8, 46·4 and 25·8 tons per square inch, respectively.

6. *Extension.*—The measurements required under this head were made symmetrically about the inch or half-inch within which fracture occurred, the missing spaces of the shorter portion of the bar being obtained, where necessary, by doubling the measurements made on the available datum inches or half-inches of the longer portion and adding these in order to the previous totals. To obtain the net elongation along the centre line, the breadth of the gap at the fracture was deducted from these overall dimensions. Owing to the fact that rupture generally begins in or about the axis of a bar and progresses out towards metal which is still stretching, the breadth of the gap is usually a maximum at or near the centre of the width of a rectangular test-piece.

From the measurements of the net stretch, the mean extensions on fixed lengths of 1, 2, 3, . . . 15 in. for each set of bars were computed and plotted to a large scale against the length. Irregularity in value of the extensions of any bar, due to lack of uniformity in the distribution of elongation in the portions of the bar outside the reduced region, was to a great extent modified on taking the average for the set of bars. This effect, commonly attributed to variation of hardness, is more probably due to variation in the average orientation of the crystals, deformation by slips being thus more easily effected in some parts than in others. The authors have observed the edges of a wide flat bar become distinctly corrugated before the maximum load was reached. These large-scale extension-length curves were of great value, for from them could be found for a given width the extension on any datum-length, fixed or variable, from 1 in. to 15 in.

Several curves of extension, for fixed lengths and for lengths proportional to the square root of the area, were drawn to a base of $\frac{\text{width}}{\text{thickness}}$. For each metal and class of gauge-length these curves were of the same type. For the sake of brevity, only the figures and curves for the British standard gauge-length of 8 in. and the German standard of $11\cdot3\sqrt{\text{area}}$ are given in this paper. To bring out clearly the nature of the variation of extension with width, the values listed in Table III. have been plotted to a somewhat open vertical scale, the resulting curves being shown in Figs. 1, 2 and 3.

The variation is very marked in the case of the 8-in. gauge-length, but much less so in that of the gauge-length $11\cdot3\sqrt{\text{area}}$. For the thicker steel, the maximum variation on the constant gauge-length is from 22·29 per cent. to 32·47 per cent., and on the variable gauge-length, from 27·28 per cent. to 29·48 per cent., or approximately 10 per cent. and 2 per cent. respectively. The corresponding variations in the case of the thinner steel are from 22·45 per cent. to 29·75 per cent., and from 28·35 per cent. to 31·14 per cent., or approximately 7 per cent. and 3 per cent. respectively. For the copper, the extension varies from 32·92 per cent. to 45·72 per cent., or roughly, 13 per cent. on the 8 in., and from 39·30 per cent. to 46·13 per cent., or roughly, 7 per cent. on the $11\cdot3\sqrt{\text{area}}$ gauge-length. These results demonstrate the undeniable superiority of a datum-length proportional to the square root of the area. The defect from constancy in the third, fifth, and seventh columns of Table III., is due to the lack of strict geometrical similarity in the test-bars, only one linear dimension of the section being varied. Within the limits of the sectional dimensions used in practice, flat specimens marked off in terms of such a gauge-length may be regarded as virtually similar bars.

An examination of the extension curves for the steel plates, Figs. 1 and 2, reveals similarity of type within the limits of comparison. It is observed that, for both thicknesses, the extension on 8 in. rises rapidly as the ratio of width to thickness is increased from 2 to 7, remains almost constant or shows a slight fall between the values 7 and 12 of the ratio, then again rises at about its former rate till the ratio reaches the value 17 (Fig. 2); the difference between these numbers, taken in order, is constant. Thereafter, as drawn, the curve for the ½-in. steel shows no semblance of periodicity.

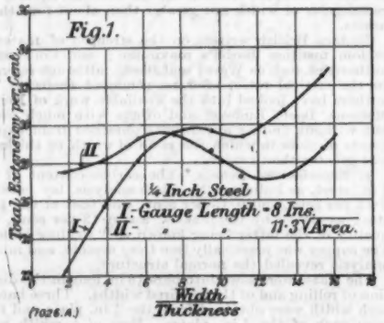
The similar curve for the copper, shown in Fig. 3, also presents, within comparable limits, a variation in form almost the same as that of Fig. 1, but the critical values of the abscissæ are different. In this case the initial rise extends from the ratio 2 to the ratio 10; a distinct depression then follows, after which another rise, lying between the ratios 18 and 26, occurs; finally, there is a drop; again, the difference between the critical values of the ratio is constant. Regarding the very high value of the extension obtained from the 3¼-in. set of bars, it may be stated here that a 3¼-in. bar, specially prepared

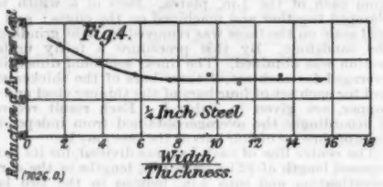
TABLE I.—DIMENSIONS OF TEST-BARS.

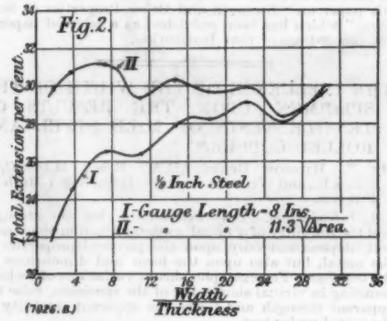
	¾-in. Steel.			½-in. Steel.			¼-in. Copper.		
Nominal Width.	Width.	Thickness.	Width. / Thickness.	Width.	Thickness.	Width. / Thickness.	Width.	Thickness.	Width. / Thickness.
in.	in.	in.		in.	in.		in.	in.	
¾	—	—	—	0·246	0·136	1·81	0·251	0·132	1·90
½	0·450	0·255	1·76	0·494	0·135	3·66	0·489	0·130	3·76
1	0·967	0·254	3·81	1·000	0·136	7·35	1·000	0·130	7·69
1½	1·443	0·256	5·64	1·494	0·136	10·98	1·486	0·132	11·26
2	1·947	0·257	7·57	2·007	0·137	14·65	2·000	0·133	15·04
2½	2·478	0·259	9·57	2·500	0·137	18·25	2·496	0·135	18·49
3	2·897	0·260	11·14	2·991	0·136	21·99	2·994	0·134	22·34
3½	3·451	0·259	13·32	3·505	0·135	25·96	3·488	0·133	26·22
4	3·955	0·257	15·39	4·006	0·134	29·89	3·997	0·134	29·83

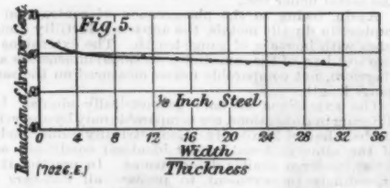
TABLE II.—YIELD POINT, TENACITY AND MEAN BREAKING STRESS.

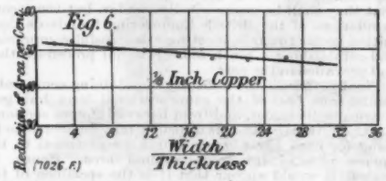
	¾-in. Steel.			½-in. Steel.			¼-in. Copper.		
Nominal Width.	Yield Point.	Tenacity.	Mean Breaking Stress.	Yield Point.	Tenacity.	Mean Breaking Stress.	Yield Point.	Tenacity.	Mean Breaking Stress.
in.	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.
¾	—	—	—	12·89	22·09	46·4	7·32	14·55	25·3
½	18·17	25·26	54·3	12·76	22·19	45·5	7·40	14·47	26·1
1	18·28	25·32	50·6	12·74	22·22	46·6	7·20	14·60	26·4
1½	18·29	25·45	48·8	12·70	22·26	45·9	7·22	14·58	25·7
2	18·10	25·45	46·0	12·76	22·47	46·0	7·30	14·54	24·9
2½	18·08	25·47	49·9	12·87	22·53	45·7	7·26	14·38	25·6
3	18·00	25·40	47·9	12·95	22·53	47·4	7·38	14·48	25·6
3½	18·05	25·66	50·0	12·90	22·46	47·2	7·41	14·56	26·3
4	18·16	25·87	50·7	12·82	22·55	46·8	7·35	14·50	25·5











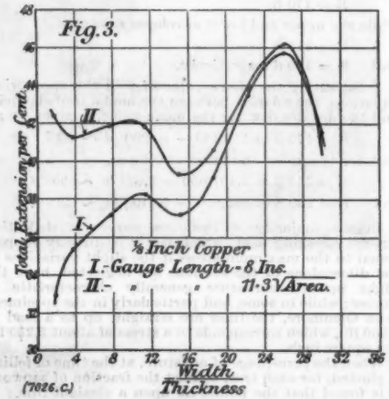


TABLE III.—*Extension.*

Nominal Width	¾-In. Steel. Extension Per Cent.		½-In. Steel. Extension Per Cent.		¼-In. Copper Extension Per Cent.	
	Gauge-length, 8 In.	Gauge-length, 11·3× √Area.	Gauge-length, 8 In.	Gauge-length, 11·3× √Area.	Gauge-length, 8 In.	Gauge-length, 11·3× √Area.
In.						
¾ ..	—	—	22·45	29·85	32·92	42·34
½ ..	22·29	27·57	24·56	30·73	35·36	41·30
1 ..	25·69	28·13	26·59	31·14	37·19	41·90
1½ ..	28·15	29·24	26·45	29·40	38·27	41·84
2 ..	29·48	29·48	27·04	30·33	37·22	39·30
2½ ..	29·61	28·51	28·27	29·70	39·20	40·64
3 ..	29·35	27·32	29·14	29·94	43·51	43·90
3½ ..	30·71	27·28	28·11	28·35	45·72	46·13
4 ..	32·47	28·68	29·75	29·56	41·57	41·32

and broken out of curiosity, gave a point on the curve and lying about midway between the points for the 3-in. and 3½-in. bars. All three curves for the 8-in. gauge length have thus certain features in common, of which the maximum at the end of the first and most regular portion is doubtless that discovered by Barba. The general trend is upwards. The curves of extension for the gauge-length $11 \cdot 3 \sqrt{\text{area}}$ are shown beside their respective curves for the constant gauge-length. The relatively small difference between the extreme values, already commented upon, is very obvious.

Plotted to a closer vertical scale, the points of Fig. 2, for instance, might be regarded as lying on or about a smooth curve of the general form $y = a + b x^n$, where a, b and n are constants. If that assumption be correct, there is no further difficulty. Assuming, however, that the succeeding maxima and minima represent the real condition, the following tentative theory is advanced to account for the phenomenon.

If the type of contraction were geometrically constant, the extension would increase continuously with the width, the gauge-length remaining fixed. The fact that the extension does not do so suggests that there is some change in the process of deformation whereby less contraction, and, therefore, less extension is produced in a wide bar than in a narrow one. On the other hand, the extension on a fixed length of a wide bar is greater than that of a narrow bar because the length is relatively less. These two contrary factors would influence the magnitude of the extension in opposite directions, and, within certain limits of the ratio of width to thickness, which probably occur in cycles, might approximately neutralise each other. Outside of these limits, shorter relative length is the determining factor, and the values of the extension tend upwards. It has been shown elsewhere* that the proportional reduction in width, and consequently the extension in the contracted region, is actually less the wider the bar.

Tests on bars varying in width by ¼ in. or less would be most helpful in clearing up much of the difficulty which surrounds this subject. From results such as the above, it is impossible to generalise; further research is necessary. As a matter of fact, the authors are at present engaged on tests of three thicknesses of boiler plate, all of which were rolled from slabs cut from a single ingot.

7. *Reduction of Area.*—The percentage reduction of area is considered by some engineers to be the true measure of ductility, and is employed by them in preference to the percentage of elongation. The determination of the minimum area of a broken test-bar is, however, a matter requiring time and care; and, further, small local defects affect the reduction to a considerable extent. As a matter of fact, the two measures of ductility are definitely related; but the connection holds only when the extension is computed as on an elemental length within the stricture and traversed by the fracture. The results obtained under this head are listed in Table IV. and shown plotted in Figs. 4, 5 and 6; they indicate the nature of the variation of this index of quality with change in the width of the specimen.

TABLE IV.—*Reduction of Area.*

Nominal Width.	¼-In. Steel. Reduction of Area.	½-In. Steel. Reduction of Area.	½-In. Copper. Reduction of Area.
In.	Per Cent.	Per Cent.	Per Cent.
¼	—	62·1	51·7
½	64·1	60·4	52·1
1	59·5	59·8	51·7
1½	56·2	59·2	49·9
2	54·9	58·6	48·2
2½	56·2	58·1	47·6
3	54·0	57·5	47·1
3½	56·0	57·0	47·8
4	54·7	57·4	46·2

The reduction of area for the ¼-in. steel bars, drops rapidly in value as the ratio of width to thickness is increased from 2 to 6, then remains practically constant up to the value of 16 of the ratio. The difference between the extreme values is 10 per cent. It is probable that the curve of Fig. 4 is not quite correct; one more like those of Figs. 5 and 6 would doubtless be a better representation. Similarly, the reduction curve for the ½-in. steel bars drops rapidly between the ratios 2 and 6, then falls gently but steadily towards the ratio 32. The values of the reduction, in this case, are most satisfactory, the maximum variation being 5 per cent. The best curve for the copper bars is obviously a straight line which has no initial drop and which falls a little more steeply than that of the ½-in. steel. The variation in this case is 6 per cent.

The results obtained from the thinner steel and the copper are more reliable than those obtained from the thicker steel, greater care having been taken in the former cases to secure accurate measurements of the minimum section. The fall in the value of reduction of area with increase in width, shown in Table IV., and in Figs. 4, 5 and 6, supports the statements made in the theory advanced in the previous paragraph. Further, as actual measurement shows that the final thickness is practically constant for all widths of specimen, the decline in the percentage of reduction of area is due to a gradual diminution in the proportional reduction of width. Unfortunately, space forbids a discussion of this matter.

* Gordon and Gulliver. Trans. Roy. Soc. Edin., 1911–12, vol. xlviii., pages 195–214.

In conclusion, the thanks of the authors are due to Dr. G. H. Gulliver, of Kirkaldy's Testing Works, London, to their colleague Mr. J. B. Todd, and to the Carnegie Trust for the Universities of Scotland.

AN EXPERIMENTAL INVESTIGATION OF THE MECHANICAL PROPERTIES OF STEELS AT HIGH TEMPERATURES*

By E. L. DUPUY (Paris).

LITERATURE relating to the mechanical properties of steel when hot is somewhat scanty, besides which the experiments have generally stopped short at a temperature of about 750 deg. C., that is to say, in the neighbourhood of, if not actually below the transformation points on heating. Only a few of these experiments will be referred to here. Vallon (1875) records special brittleness in steel heated to blueness, and instances the following experiment: If an iron or steel rod be heated to redness, and be subjected during the cooling to bending flat a number of times, it is found that at a certain temperature, corresponding with blue heat, cracks develop on the deformed portions, whereas if bending be effected at higher or lower temperatures no flaws are produced. Ledebur, referring to red-short metals, points out that

Fig.1. METHOD OF CUTTING THE BARS.

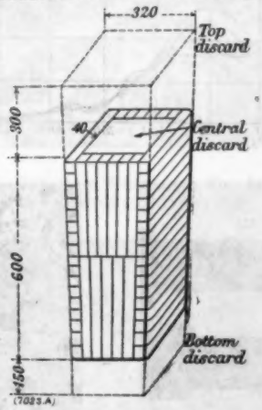


Fig.3. TEST-PIECE. NORMAL TYPE.

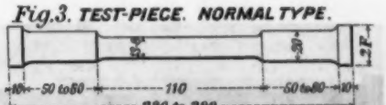
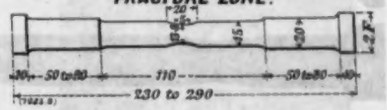


Fig.4. TEST-PIECE WITH CONTRACTED FRACTURE ZONE.



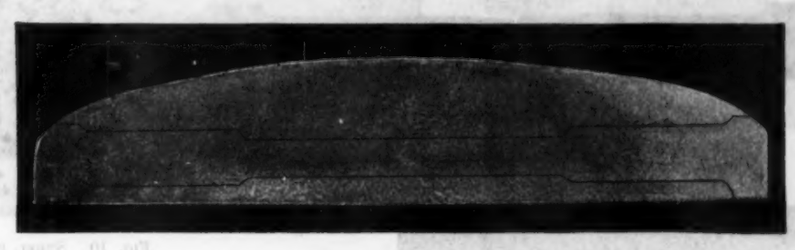


FIG. 2. STEEL WITH 0·44 PER CENT. CARBON AS CAST. MACROGRAPH, SHOWING HOW TEST-PIECE WAS CUT FROM BAR (HALF NATURAL SIZE).

in regard to some of them the loss in malleability only occurs within a certain temperature range, above or below which they recover their former properties. Codron (1896) studied the load required to reduce, by slow compression, the height of iron and steel cylinders of various grades to one-half, as well as the breaking stresses and the reduction in area in the same samples. These tests were made at temperatures up to 1,500 deg. C. The temperatures were judged by the eye from the colour of the test-pieces, and must be admitted to be inaccurate within some hundreds of degrees. The curves he obtained for similar properties in different steels had the same general appearance, the hardest steel being one containing 0·6 per cent. of carbon. The breaking and crushing loads increase somewhat towards 300 deg. C. and then decrease, first rapidly and then more slowly, and become nil at 1,500 deg. C. The curves relating to reduction of area are more complicated, being, to begin with, horizontal, then falling towards 250 deg. C.; showing a minimum at 375 deg. C., and thereafter rising until, at 500 deg. C., they reach 90 per cent. Between 1,200 deg. and 1,300 deg. they fall to zero. André Le Chatelier published in 1900 an important investigation of the mechanical properties of steel at high temperatures. The experiments were made on mild rolled steels. The reduction of area which, to begin with, decrease slightly when the temperature rose, showed a sharply marked minimum at about 450 deg. It then increased rapidly, exhibited a bend at 900 deg., and again rose until, at about 1,200 deg., it reached 95 per cent. The temperatures were very accurately measured by means of a Le Chatelier thermocouple, but the points taken experimentally in the region of the critical temperatures being few in number only show the general trend of the phenomena. Brinell (1905) investigated the ball hardness of two steels containing 0·17 per cent. of carbon at different temperatures. The curves revealed an increase in hardness at 250 deg. C., followed, from 500 deg. upwards, by a decrease, which to begin with was rapid but became slower. Robin (1908) found similar results when measuring the hardness of steels of varying grades. Guillet and Revillon (1909) gave impact resistance values for various steels at temperatures between the normal and 600 deg. The various curves, after giving a slight maximum at about 180 deg. C., showed a bend up to 500 deg. C. and then rose rapidly.

From these various investigations it is, in short, only possible to gather that between about 300 deg. and 400 deg. C. steel displays a blue-heat brittleness characterised by an increase in the tensile strength and a well-marked reduction in area, followed by a uniform diminution in the tensile strength and an increase in the reduction of area. The latter reaches from 95 per cent. to 100 per cent. at between 1,000 deg. C. and 1,300 deg. C. On the other hand, the passage through the transformation points is not attended with any special anomaly.

Rosenhain and Humphrey (1913) carried out an exceedingly careful series of experiments, with the object of ascertaining the influence of the transformation points on the tensile strength and on the mode of fracture. They employed sheets of electrolytic iron, or of dead soft steel containing 0·1 per cent. of carbon. The section across the fracture was about 1 by 3·18 mm. To obviate oxidation the furnace and test-pieces were placed *in vacuo*. The observations were taken on a cooling temperature curve, the test-pieces being heated to 1,100 deg. C. and then cooled to the temperature required. Only the breaking stresses were recorded. The elongations yielded irregular results, and the reductions of area were not measured. The resulting temperature-breaking-stress curve displayed two clearly marked discontinuities, and a third, which was doubtful. The two former discontinuities corresponded respectively with the points Ar1 and Ar2 of the metal under investigation, but the third occurred at about 30 deg. higher than Ar3.

As will be shown in the conclusions arrived at in the present investigation, the author is not quite in agreement with Rosenhain and Humphrey in regard to the correspondence between the anomalies and the critical points of the metal. Quite recently, and when the present investigation was almost completed, the author heard of a memoir presented by Mr. Gouvy before the Society of Civil Engineers of France, giving certain details relative to the manufacture and properties of Armco iron. This metal, which is neither more nor less than extra pure steel containing less than 0·02 per cent. of carbon, displays the peculiarity of not being capable of being forged or rolled between 850 deg. and 990 deg. without cracking. It possesses, within this range, a degree of brittleness which renders any working impossible.

The investigations summarised in the present research had as their object the determination of the mechanical properties of steels in respect of their carbon percentages, at all temperatures between the normal and incipient fusion. Further, in order to ascertain what might be the influence of the size and orientation of the grains on these properties, experiments were carried out upon both cast and rolled material.

Steels Employed.—Five grades of open-hearth steels were selected, the analyses being shown in the table given on page 392.

Test-Bars.—From each of the casts selected two square ingots, 1 metre long and 320 mm. by 320 mm. in section, were chosen, from one of which the unworked bars were taken, while from the other bars were cut after rolling.

Bars Cut from the Ingot.—The test-bars were sawn

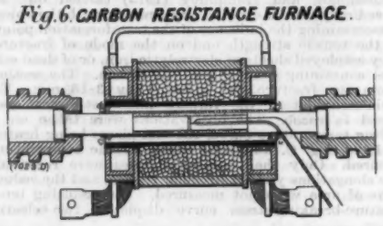
*Paper read at the Paris Meeting of the Iron and Steel Institution, Tuesday, September 6, 1921.

cold from the air-cooled ingot, and underwent no heat treatment of any kind. In order to ensure the metal being sound, free from piping, and capable of yielding bars crystallically identical, vertical slices, 40 mm.

Mark.	Carbon.	Manganese.	Silicon.	Phosphorus.	Sulphur.
29	0·15	0·46	0·06	0·014	0·034
61	0·44	0·63	0·15	0·005	0·020
27	0·55	0·70	0·52	0·014	0·023
45	0·92	0·44	0·24	0·019	0·027
57	1·23	0·35	0·25	0·014	0·025

in thickness, were cut, after discarding 30 per cent. from the top of the ingot, parallel with the sides (Fig. 1). These slices were subsequently sawn into pieces 30 mm. thick, from which the test-bars were turned. Centring on the lathe was effected in such manner that the centre of the section in which fracture would occur was within

Fig. 6. CARBON RESISTANCE FURNACE.



a diameter of 13·8 mm. Figs. 3 and 4 give their dimensions. They were made by turning the bars down to a diameter of 14 mm. and finishing on an emery-wheel with an abundant water supply to obviate heating. In some instances it was necessary to employ bars in which

Fig. 5. PLATINUM RESISTANCE FURNACE.

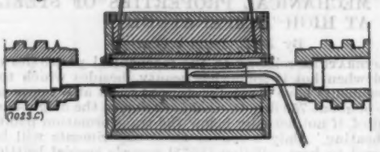


Fig. 8. CARBON, 0·15 PER CENT.

—As Cast. ——Rolled.
— C. and Heated. -----Rolled and Heat Treated.

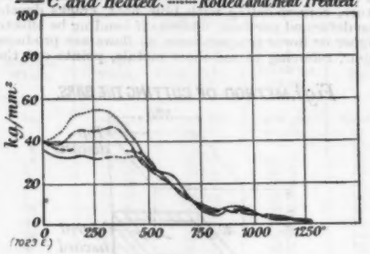
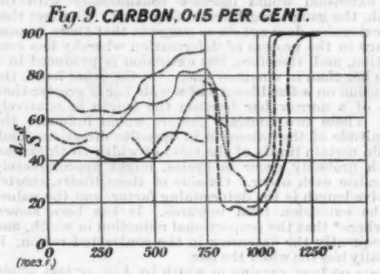


Fig. 9. CARBON, 0·15 PER CENT.



within about 200 grammes per square mm. The error involved would therefore be less than that arising from irregularities in the bars themselves. In this type of machine the test is effected at a constant rate of elongation. The author carried out the tests uniformly at a rate of 12 mm. elongation per minute. The machine is driven by an electric motor, which enables it to work without either shock or recoil.

Heating Arrangements.—Two different sets of arrangements were employed for the heating according as the tests were to be effected above or below 1,250 deg. C.

Tests made below 1,250 deg. C.—The bar was placed in the axis of a platinum tube-resistance furnace 160 mm. in length and 32 mm. in interior diameter (Fig. 5). The metal is protected from oxidation by sheathing the 13·8 mm. diameter portion in sheet metal resting on the projecting shoulder of the test-piece. The intervening portion was packed either with steel filings or with wood charcoal. Comparative tests showed that both modes of protecting the bars gave identical results from the point of view of the mechanical properties on heating.

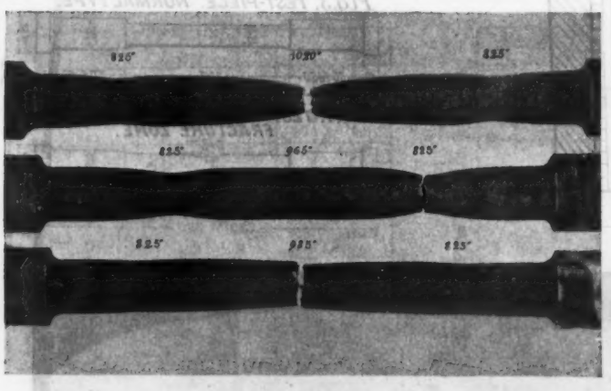


Fig. 7. STEEL WITH 0·15 PER CENT. CARBON. ROLLED.

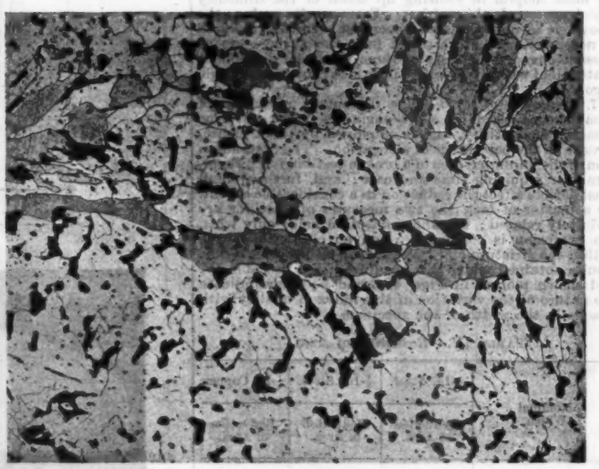


Fig. 10. STEEL FROM THE CAST INGOT; ALONG THE LONG AXIS OF TEST-BAR. × 35. ETCHED WITH NITRIC ACID IN ALCOHOL.

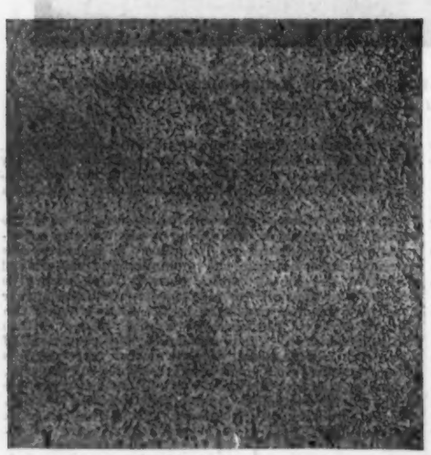


Fig. 11. THE SAME AS FIG. 10, AFTER HEAT TREATMENT.

Fig. 12. CARBON, 0·44 PER CENT.

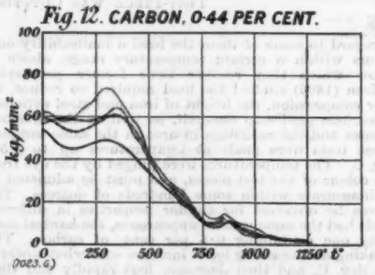
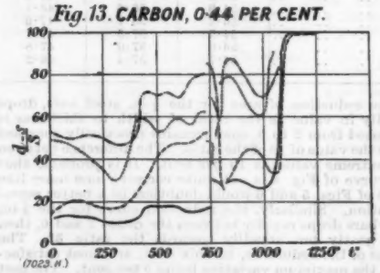


Fig. 13. CARBON, 0·44 PER CENT.



30 mm. of the sides of the original ingot (Fig. 2). It resulted from this method of cutting the bars that their centre axes were either parallel with, or at right angles to, the axis of the ingot. Comparative tests showed that the mechanical properties were the same in either case.

Rolled Bars.—The ingot selected for furnishing the rolled bars was first cogged down to square billets 105 mm. by 105 mm., which, after cooling, were reheated and re-rolled to rounds having a diameter of 27 mm.

Dimensions of the Bars.—The section for fracture selected was one of 150 square mm., corresponding with a crack had already developed. In such cases the bars were 16 mm. in diameter, with a centre portion further reduced, for a length of 5 mm., to 13·8 mm., and shouldered off at each end (Fig. 4).

Treated Bars.—The treatment for the whole series of tests consisted of placing the bars in a cold furnace and heating them up over a period of 1½ hours to 925 deg. C. The temperature of heat treatment once attained was kept constant for 10 minutes in order to ensure uniformity of temperature between the centre and the surface of the bars. This annealing was followed by cooling in still air. The treatment was carried out on worked bars 16 mm. in diameter, the reduction to the final dimensions being made after the heat treatment.

Method of Testing.—The tests were carried out on a 50-ton loaded-beam Falcot machine, the reading of the load being taken on a mercury manometer, which allowed for the readings being within about 25 kg., that is to say, in the case of bars 150 square mm. in section to within about 200 grammes per square mm. The error involved would therefore be less than that arising from irregularities in the bars themselves. In this type of machine the test is effected at a constant rate of elongation. The author carried out the tests uniformly at a rate of 12 mm. elongation per minute. The machine is driven by an electric motor, which enables it to work without either shock or recoil.

Tests above 1,250 deg. C.—In the tests carried out at very high temperatures the platinum resistance furnace was replaced by another furnace of the same dimensions, but in which the heating portion consisted of a carbon tube subjected to a current about 400 amperes at 12 volts (Fig. 6). An arrangement of rings cooled by flowing water protected the ends of the test-pieces from being overheated. In these tests the bars were always placed in mild steel filings in order to avoid the formation of a cement-iron skin, due to the action of the carbon protecting sheath.

Measurement of the Temperatures.—The hot junction of a platinum-platinum-rhodium Le Chatelier pyrometer was fixed by means of a ½ mm. nichrome wire, so as to be in contact with the central portion of the bar. The electromotive force read by means of a millivoltmeter enabled the temperature of the thermocouple, and therefore the control of the heating, to be regulated within about 2 deg. The thermocouples were calibrated by taking as fixed points the boiling of napthalene

(219 deg.), boiling sulphur (445 deg.), and the melting of copper (1,088 deg.), and by calculating from these values the coefficients of the formula :

$$V = a + bt + ct^2.$$

The couples were invariably re-standardised twice a week, hence no divergence over 0·05 millivolt ever occurred at the 1,088 deg. point.

Heating the Bars.—The regulation of the heating was always carried out in such a manner as to attain the required temperature at the rate of 20 deg. per minute. Heating was carried up to a temperature of 10 deg. higher than that which it was desired to attain, and five minutes were taken in cooling down to the final temperature selected. This method of operating secured the equalisation of the temperature throughout the whole fracture-section of the bar. Every endeavour was taken to make the method of operating as systematic as possible, so that errors due to such causes as unequal heating, discrepancies between the temperature of the thermocouple and that of the centre of the bars, &c., were constant. The results obtained may, so far as their absolute values are concerned, be subject to slight allowances, but they are none the less comparative.

Experimental Results.

Steel containing 0·15 per cent. of Carbon. Figs. 7 to 9. 1. *Steel as Cast.*—The breaking stress in the cold was 34 kg. per square mm. It remains practically constant up to about 500 deg., although showing a slight maximum at about 250 deg. It then diminishes uniformly up to 750 deg., at which temperature breaking occurs under a stress of 9 kg. Above this point the curve exhibits a slight degree of discontinuity. It falls, but increasingly slowly, until it reaches 825 deg. C. The first sample tested above this temperature—that is to say, at 900 deg.—did not break through the middle, but showed two contractions equi-distant from the middle of the bar, and at one of which fracture took place (Fig. 7). As, owing to the arrangement of the furnace, the middle of the bar would be hotter than the extremities, this anomaly appears to show that the breaking stress traverses a minimum and subsequently rises. Instead, therefore, of the bars hitherto employed, a bar of the type narrowed down for 5 mm. was used in order to induce fracture in this region, the temperature of which was measurable. In this case a test carried out at 775 deg. showed a breaking stress of 6 kg. per square mm. This U-shaped curve, Fig. 9, continued up to 870 deg., the temperature above which the load began to decrease. The contraction at 16 deg. was 35 per cent. At 200 deg. and at 600 deg. it presents maxima, followed by slight stepping, and at 750 deg. it reaches 48 per cent. At this point a discontinuity occurs and it rises to 54 per cent. It falls rapidly thereafter to 14 per cent. at 950 deg., and then increases afresh and reaches 100 per cent. at 1,200 deg. These variations in two measurable quantities, breaking stress and reduction of area, are accompanied, as will be seen later, by variations in the appearance of the fractures.

2. *Metal as Cast and Heat Treated* (*Figs.* 10 *and* 11).—Annealing at 925 deg. followed by air-cooling slightly modifies the mechanical properties of the metal, while preserving the same general characteristics. An examination of the curves, Figs. 8 and 9, shows that the breaking stress in the cold increases by 6 kg. per square mm., this difference diminishing gradually in proportion as the temperature rises. The reduction is similarly increased to a notable extent. The improvement is particularly noticeable between 600 deg. and 750 deg.

3. *Rolled Metal.*—The very heavy working which the metal had undergone during rolling (a reduction of 100 to 1) had very little influence on the breaking stress, and the curves all preserve the same general characteristics. Reduction of area is on the contrary, markedly increased; it reaches 100 per cent. in the neighbourhood of 150 deg., that is, at a lower temperature than the cast metal, and remains constant up to 1,400 deg. It then falls suddenly to zero simultaneously with the breaking stress.

4. *Rolled Metal Heat-Treated.*—The influence of annealing is particularly marked below 750 deg. Within this range the reduction of area which falls from 71 per cent. to 62 per cent. between 150 deg. and 350 deg. (blue brittleness) rises thereafter, and at 750 deg. reaches 91 per cent.

Steel containing 0·44 per cent. of Carbon. (*Figs* 12 *to* 16).—Steel containing 0·44 per cent. of carbon behaves very similarly to dead soft steel. Up to about 750 deg. the steel, as cast, breaks almost without contraction. Annealing improves the contraction at low temperatures, raising it from 12 or 15 per cent. to 20 per cent., but its influence is more particularly marked at 450 deg. and upwards, a temperature at which the malleability of the metal begins to increase and eventually reaches 70 per cent. at 750 deg.

Rolling further increases this ductility, and after showing a minimum at about 300 deg. the contraction increases rapidly between 350 deg. and 400 deg., and then more slowly, ultimately reaching 65 per cent. at 750 deg. for the untreated rolled metal, and 85 per cent. for the heat-treated rolled metal. The breaking stress decreases slowly to begin with when the temperature rises, shows a minimum between 120 deg. and 150 deg.; then rises up to 300 deg., and thereafter diminishes uniformly up to 750 deg. The curves corresponding with the breaking stresses under the different conditions are parallel with each other. At 750 deg. the two series of curves show a discontinuity, Fig. 13. The reduction of area undergoes a sudden increase followed by a diminution. It then rises, and after again falling at about 1,000 deg., increases rapidly until it reaches 100 per cent. at 1,100 deg. The breaking stress shows a minimum at 610 deg., rises thereafter up to 850 deg., and falls uniformly until fusion point is reached.

Steel containing 0·55 per cent. of Carbon. (*Figs.* 17 *to* 24).—The curves showing the variations in the

Fig. 14. 0·44 per cent. Carbon Steel as Cast. Section at Right Angles to Longitudinal Axis of Bar. × 37.

Fig. 15. The same Steel as in Fig. 14; Section along Longitudinal Axis of Bar. × 37.

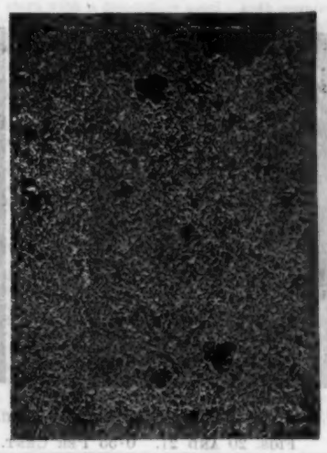
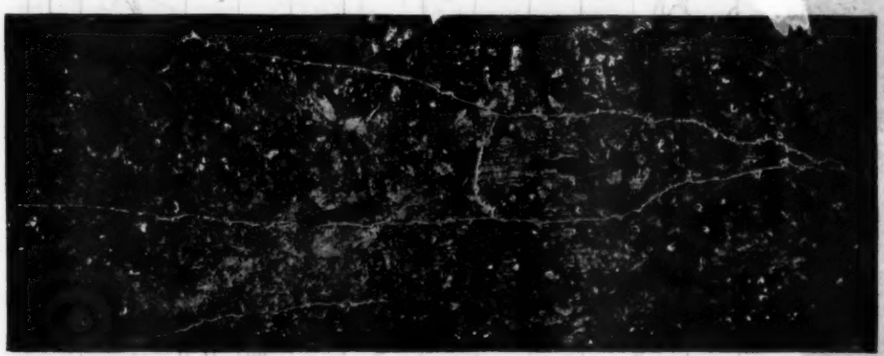
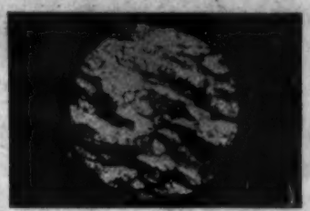


Fig. 16. The same Steel as shown in Figs. 14 and 15. Heat Treated. × 37.





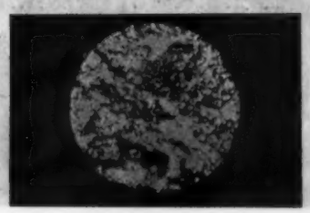


Fig. 18. The same Steel as shown in Fig. 17, showing Zone of Fracture across Plane Perpendicular to Axis of Test-Piece. × 37 and Reduced Four-Fifth Size.

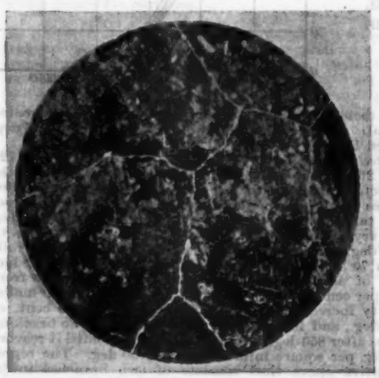


Fig. 19. The same Steel as in Fig. 18, but across Axis. × 37.

Fig. 17. Steel Containing 0·55 per Cent. of Carbon, as Cast at 725 and 785 deg. respectively. × 2.

mechanical properties of steel containing 0·55 per cent. of carbon, Figs. 23 and 24, divide below 775 deg. up to 800 deg. into two groups. These groups correspond, on the one hand, with the metal as cast, and on the other with the metal as heat treated or rolled. The steel as cast breaks below 800 deg. with a very small reduction in area. From this point there is a sudden improvement, the reduction in area increases from 7 per cent. to 45 per cent., and remains in this neighbourhood up to about 1,000 deg., and becomes 99 per cent. at 1,125 deg. Towards 1,400 deg. it suddenly falls to nil. The breaking stress, which commences at 66 kg. per square mm., falls at first, but recovers a little later and becomes 65 kg. at 360 deg. It then falls, at first, slightly, and then more rapidly above 550 deg. At 880 deg. it exhibits a discontinuity. The fracture alters its appearance at this temperature; whereas below 800 deg. it occurs, owing to a parting between the pearlite grains, above that temperature a new structure is seen (Fig. 17). The curve takes a U-form until it reaches 940 deg. Above this temperature it again falls uniformly to about 1,400 deg., at which it suddenly falls from 1·3 kg. per square mm. to nil. In regard to the second group, the reduction of area remains in the vicinity of 25 per cent. to 30 per cent. at 375 deg. It then rises rather rapidly and exhibits a step between 400 deg. and 500 deg., falls to a minimum at 600 deg., and continues with some oscillations up to 775 deg., when it exhibits a discontinuity. The diminution in the area increases suddenly and then falls at 900 deg. It again rises, and at 980 deg. reaches 99 per cent. The breaking stress after showing a slight minimum at 175 deg. rises up to 310 deg. After that maximum it falls uniformly up to 900 deg., when there is a slight discontinuity followed by a few oscillations, and uniform diminution commences above 940 deg.

The micrographic examination affords a reason for the causes of this difference between the steel as cast and as heat treated. It shows that in the cast steel the structure is almost wholly pearlitic with crystallites of thin streaks of ferrite in the joints. The structure is therefore abnormal, showing that the apparent carbon content is in the neighbourhood of that corresponding with the eutectic. The fracture, as shown in Figs. 20 to 23, of test-pieces before and after fracture, occurs in the ferrite of the joints without the pearlite areas being markedly deformed. As these joints are extremely thin their deformation does not appreciably modify the section of the sample after fracture. On the other hand, after heat treatment and, *a fortiori*, after rolling, the excess of ferrite is expelled from the pearlite, thus allowing a far greater reduction in area in proportion to the actual percentage of carbon. Once the A1 point has been passed the appearance of austenite makes the structure of the cast metal resemble more closely that of the heat-treated metal. Hence the similarity of the curves above 775 deg. (Figs. 18–22).

Steel containing 0·91 per cent. of Carbon. (Figs. 25 and 26.)—This composition corresponds with that of the eutectoid steel up to 450 deg., and whether the test-pieces cut from the ingot are heat treated or not fracture takes place owing to brittleness and occurs between the crystallite (Figs. 25 and 26). From 450 deg. to 800 deg. the breaking stress of the metal as cast falls from 70 kg. to 9 kg. per square millimetre. The reduction of area within this range increases slowly from 4·5 per cent. to 8·6 per cent. At this point the malleability increases suddenly and reaches 98 per cent. at 850 deg., and 100 per cent. shortly after. The breaking stress after 850 deg. decreases more slowly until it reaches 1·7 kg. per square millimetre at 1,150 deg. The representative curve thus consists of two branches intersecting each other at 800 deg. Heat treatment does not appreciably increase the tensile strength. The reduction of area, on the other hand, is markedly modified in the region below 800 deg. Starting with 43 per cent. at 400 deg. the curve falls, to begin with, to 33 per cent. at 600 deg., and the rapidly rises to 99 per cent. at 800 deg.

The properties of the rolled metal are closely similar whether it has been heat treated or not. The breaking stress first rises up to about 325 deg., where it reaches 113 kg. per square millimetre in the untreated metal, and 118 kg. per square millimetre in the heat-treated metal. It falls subsequently up to 800 deg., at which point the curves coalesce. At still higher temperatures the breaking stresses are practically independent of the amount of working or of the heat treatment of the metal. The two curves relating to reduction in area behave similarly; that of the heat-treated metal being slightly higher than that of the untreated rolled metal. On the temperature being increased the reduction in area diminishes slightly from 14 per cent. to 16 per cent. down to 10 per cent. at 325 deg., Fig. 26. The curve then rises almost vertically, and exhibits a maximum of 55 per cent. at 400 deg., after which it falls slightly down to 40 per cent. at 575 deg., and then rises rapidly until it reaches 99 per cent. at about 800 deg., and 100 per cent. soon afterwards.

(To be continued.)

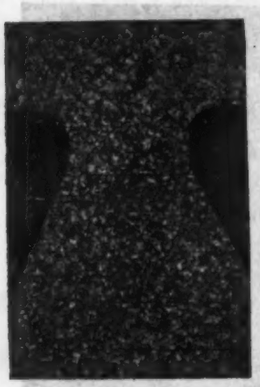


FIG. 20. (*a*) BEFORE FRACTURE.

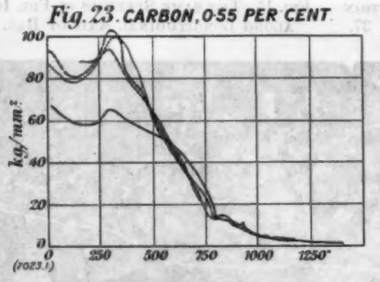
FIG. 21. (*a*) AFTER FRACTURE.

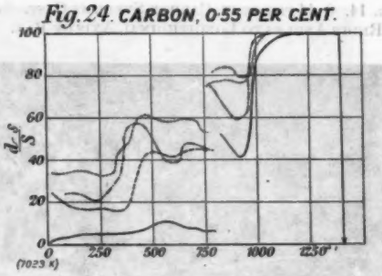
FIG. 20. (*b*) BEFORE FRACTURE.

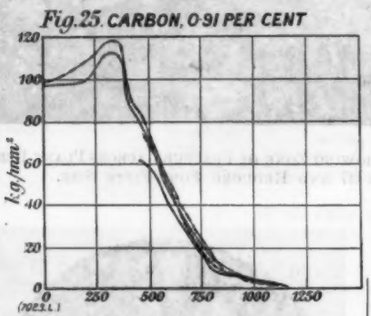
FIG. 21. (*b*) AFTER FRACTURE.

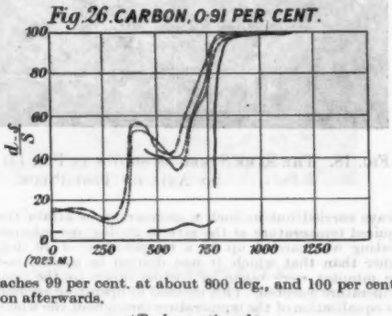
FIGS. 20 AND 21. 0·55 PER CENT. CARBON STEEL; (*a*) ETCHED WITH NITRIC ACID IN ALCOHOL. (*b*) ETCHED WITH CUPROUS REAGENT.

FIG. 22. FRACTURE OF 0·55 PER CENT. CARBON STEEL PASSING THROUGH A FERRITE JUNCTURE. × 40. SEE FIGS. 20 AND 21, ABOVE.









EXPLOSION TEST FOR BEARING METALS.—In testing explosive caps or detonators, the Metallwarenfabrik das im Baden places the cap, as is usually done, on a plate of hard lead which is separated from the base of the apparatus by a steel ring. The cap is fired by means of a fuse, and the indentation crater produced is measured as to diameter and depth. Max Dreifuss, of these works, replaced the hard lead by the bearing-metal alloys made by the firm, and found that the explosion test gave results in accord with the Brinell hardness tests. He had expected that some of the hard alloys would be shattered by the explosion to an extent, at any rate, to make crater measurements impossible; but there was no particular difficulty of this kind, though the craters were not circular; he speaks (*Zeitschrift für Elektrochemie*, pages 320 to 322) of crater-width, meaning the maximum diameter. The metal plate is generally a square plate, 55 mm. long and 12 mm. thick, lying on a steel ring which is bolted to a base; the detonator capsules used are cylindrical, 45 mm. long, 8 mm. diameter, and are placed vertically on the plate. The materials tested were lead, tin, copper, zinc, and various "stella" alloys consisting of tin, antimony, copper and lead, as well as a zinc bronze, a phosphor bronze and a grey cast-iron. Arranging the materials in order of increasing hardness, refined lead, hard lead, the above alloys, zinc bronze, phosphor bronze, cast iron, Dreifuss found that the crater diameters decreased from 14 mm. down to 7·6 mm., and the crater depth from 8·2 mm. down to 1·9 mm., in a fairly regular way. Thus the strength deduced from this explosion test would be in accord with the Brinell hardness test.

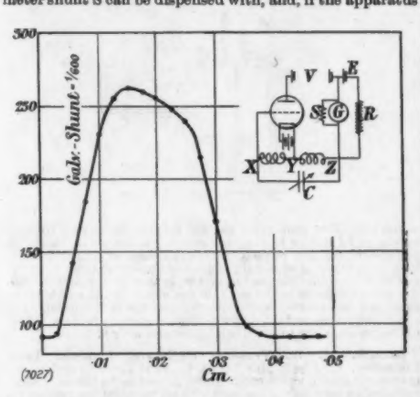
THE RECORDING ULTRA-MICROMETER.*

By JOHN J. DOWLING, M.A., F.Inst.P., M.R.I.A.

THE principle underlying the device is best understood from the following experiment, but it must be stated that the particular valve circuit here dealt with is only one of several that may be utilised. For certain purposes other arrangements are more suitable.

In the figure, the coils X Y, Y Z are small pancake coils suitably placed by trial so as to make the apparatus function as described below. The condenser C is formed by two small discs turned reasonably true. The relative motion (normally) of these produces alteration in the capacity, which causes corresponding changes in the anode current, and it is this anode current variation which is measured by the galvanometer. By means of the "zero-shunt," consisting of a few cells E, and the resistance R, both in parallel with G, it is possible to employ a sensitive galvanometer to record only the changes in the anode current (I) in the neighbourhood of a particular value $\left(I = \frac{E}{R}\right)$ thereof. If the resistance R is great compared with the galvanometer resistance, it is easy to see that practically all the difference (d I) of the anode current (I + dI) from the "standard" value (I) will go through G. Very minute changes in I are thus recorded.

The curve represents the variation in the anode current as C is changed—the variation in C being expressed in terms of the readings of a micrometer screw which moves one of the plates. It is obvious that, over two parts of the curve, the variation of I with the displacement is a simple linear one. This is a fact of great importance in simplifying the employment of the device. By employing the "zero-shunt," the galvanometer shunt S can be dispensed with, and, if the apparatus



is functioning anywhere on one of the straight parts of the curve, the extraordinarily minute displacements of the condenser plates are recorded by the galvanometer. In the example shown, a displacement of less than 10^{-7} cm. was detectable.

The apparatus, when adjusted to very high sensitivities, has to be screened, as is usual in wireless work, but it is quite steady and recovers instantly from an accidental disturbance. The "inertia" of the galvanometer is probably a large contributing cause of this steadiness.

The applications of the device already worked out include the following, and patents have been applied for covering these.

Both in the physical laboratory and in engineering, the measurement of minute strains, displacements, expansions and the like, can be carried out with a degree of refinement altogether out of proportion with the simplicity and reliability of the apparatus. All these can be made from a distance, and can be recorded by a recording galvanometer if desired. Both transverse, as well as longitudinal strain has been measured on quite small specimens (2 in. by ½ in. square) and thus all the elastic constants determined.

Weighing devices have been developed. For example, a balance weighing 200 gms. to the nearest milligram, was shown at the meeting in which the micrometer device was used to indicate, instantaneously, the difference between the weight of the substance required and the nearest whole number of grammes. To use it, weights are removed from one scale pan until the sum of the remaining weights plus the substance differs by a fraction of one gramme from 200 gms. The scale reading then directly records the outstanding difference in milligrams. A balance acting on this principle is dead-beat in action, and enables an accurate weighing to be obtained in a few seconds instead of several minutes—a great desideratum in many cases. A suitable modification of the "spring" enables weights of even tons to be determined with equal percentage accuracy.

On similar lines, an apparatus is being developed to enable minute variations in gravitational force to be observed. The decrease in weight of a kilogramme when raised one metre can be readily observed.

If one of the condenser plates is carried on a flexible diaphragm, minute pressure differences are recorded with great ease. Using a rubber diaphragm 1 mm. thick, pressures of less than 1/10,000 atmosphere are measurable to 1 per cent.

* Paper read before Section A of the British Association at Edinburgh, September 8, 1921.

Incorporated in seismometers, such considerable magnification is obtainable as to make it possible to introduce enormous damping. Much smaller instruments are likewise possible, while great sensitiveness, and its concomitant delicacy of adjustment, are no longer so necessary in the seismometer instrument itself.

The measurement of the "growth pulses" of plants is another problem to which the apparatus has already been applied (*Nature*, June 23, 1921), and, in its most sensitive form, it promises to yield valuable results in this as in other fields of research.

DAMASCENE STEEL.*

By COLONEL N. T. BELAIEW, C.B.

1. IN a previous paper on damascene steel,† presented to the Institute in 1918 by the author, he described the general properties and structure of damascene steel, and pointed out the great claims it had to the attention of all interested in tool steel. The object of the present paper is to substantiate that statement, more especially as regards high-speed steels. In the author's opinion a marked analogy exists in the structure and in some of the properties of high-speed and damascene steels, and a comparative study of both might, therefore, prove beneficial in explaining certain properties and in opening new vistas.

2. Damascene steel belongs to the hypereutectoid series of carbon steels. As mentioned in the author's previous paper, the average carbon content of typical damascene articles must be about 1·5 per cent. That amount of carbon, however, does not exist as such, but as a definite chemical compound, Fe_3C or cementite. Introducing the respective atomic weights of iron and carbon:

$$(3 \times 56) \text{ iron} + 12 \text{ carbon} = 180\ Fe_3C,$$

we arrive at the result, that one part of carbon produces $\frac{180}{12}$ or 15 parts of cementite. 1·5 per cent. of carbon in steel represents, therefore, 22·5 per cent. of cementite, which, from the practical point of view, is a very large amount. About one-half of this amount (11·5 per cent.) forms the excess, or free cementite. The other 11 per cent. of cementite with a corresponding amount of ferrite is used up in building up "pearlite."

The free cementite is coarser than the eutectoid cementite, its spheroidisation is correspondingly more difficult and necessitates repeated hammering and heating. The greatest care must be taken to break the large cementite needles into smaller particles and afterwards to cause their complete spheroidisation.

The Indian damascene blades, examined in Petrograd by the author, showed a perfect balling up, as may be seen from Figs. 3 and 4 of his previous paper. The completeness of the spheroidising process may be further illustrated by Fig. 1 annexed, showing, magnified by 1,000, a section of an Indian blade, photographed in the author's London laboratory by Captain B. Brandt. The larger particles shown in the section are those of "free" cementite, the smaller ones are eutectoid cementites. Both groups are thoroughly spheroidised.

Figs. 1 and 2 of the author's first paper also show what a large amount of mechanical treatment (as shown by the macrostructure of the blade) was required to attain such complete spheroidisation. The macrostructure shows also that the cementite veins run closer up to the edge, and that therefore the oriental maker must have relied most upon securing the best cutting properties of the cementite particles.

3. High-speed steel is a tool steel which possesses the property of maintaining its hardness at a relatively high temperature. This property is secured in a large degree by adding tungsten and chromium, usually 16 per cent. to 20 per cent. of the former and from 3 per cent. to 5 per cent. of the latter; the carbon content is generally not over 0·75 per cent.; up to 1 per cent. of vanadium is also added.

This steel belongs to the cementitic (carbide) series; its structure when annealed, presents a striking similarity to the structure of damascene steel (see, for instance, Fig. 336, page 356, of Sauveur's "Metallography"). Spheroidised carbide particles are embedded in a sorbitic matrix. To produce "high-speed hardness" such steel has to be heated to a very high temperature, and then quickly cooled. A certain amount of carbide remains undissolved, even after rapid cooling from temperatures close to the melting point (see, for instance, Figs. 334 and 342, Yatsevitch, in Sauveur's "Metallography"). There are even indications that a moderate amount of free carbide appears to increase the cutting properties of the tool.

The actual makers of high-speed steel, however, emphasise that the making of the high-speed structure begins under the hammer; that during this operation "the massive carbides and tungstides present in the ingot are broken down and uniformly distributed throughout the billet";‡ and further, that "to accomplish this the reduction in area must be sufficient." Therefore, ingots are first hammered into billets, the billets are again slowly heated and then hammered for a second time ("cogged")—all this "mechanical treatment" being indispensable in paving the way to the "heat treatment" by properly breaking and evenly distributing the carbides (and tungstides) throughout the steel.

4. If we proceed now to compare not only the photomicrographs, but also the two processes—the "high-speed hardness" and the "damascene" process, we see how similar they are.

Both start with a cementitic steel; both require the greatest care in breaking and evenly distributing the carbides under the hammer; in both cases the amount of mechanical work spent on a given article is very large, but however large it is considered indispensable before a suitable heat treatment may be effected. In both cases the structure of carbides is spherolitic, whilst the matrix, after the heat treatment, is martensitic. In both cases also the cutting properties of the edge are related not only to the matrix, but to the carbides as well.

The author is even inclined to think that the properties and the distribution of the carbides play a more considerable role than the matrix. On this ground may be explained the reason why, on the one hand, such diversities of opinion exist as to the structure of the matrix in high-speed steels, whilst, on the other, neither the old Eastern makers nor Anossow seemed to attach any real importance to the tempering of damascene steel. The author's studies in this field have led him to the belief that whilst being very strict as regards the hammering temperatures, nobody who has really busied himself with damascene steel cared much as to its subsequent heat treatments.

5. There are a few conclusions which can be drawn from these preliminary remarks:

First, there is the question of spheroidisation of the carbides. In damascene steel the degree of spheroidisation is always very high. That spheroidisation, however, was not an end in itself for the ancient maker, but was attained, so to say, incidentally during the numerous cautious forgings and heatings, when the greatest ductility was sought and obtained.

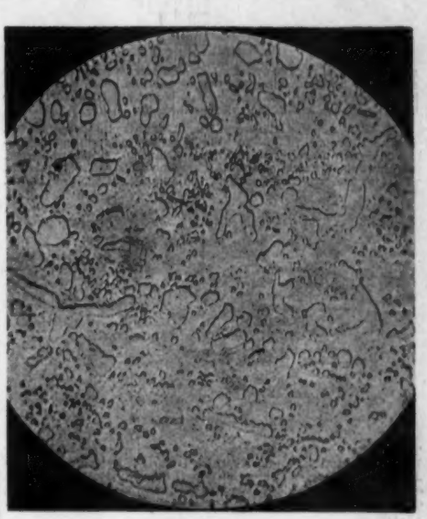


FIG. 1.—AN INDIAN BLADE FROM THE AUTHOR'S COLLECTION. GLOBULES OF SPHEROIDISED CEMENTITE EMBEDDED IN A SORBITIC MATRIX. × 1000.

In high-speed steels that spheroidisation is also attained, but it seems to the author that insufficient stress has been laid on that point, either by the high-speed steel maker, or user. He believes that a scientific application of the spheroidising process would help to improve the qualities of high-speed steel. He thinks, further, that another inference from the damascene process might be drawn, namely, the proper study of the macrostructure. An oriental maker would never manufacture a steel article without having satisfied himself, by studying the watering, that the distribution of the carbides is the best possible and quite in accordance with the shape and properties of the article. Neither would he find a buyer ready to accept a sword or a tool without a proper "metallographic" examination of it as a whole (towards that end the splendid oriental watering lent itself so well). The author, therefore, believes that a proper examination of the "watering" of high-speed steel, either in billets or in the finished article, will prove useful.

As to the damascene steels, whilst not ready to place them in the category of high-speed steels, the author is, however, inclined to think that a certain "high-speed hardness" which he noticed during his experiments on damascene steel (interrupted by the war) might prove not quite accidental, but useful for further investigation.

The author takes this opportunity to express his sincere thanks to Captain B. Brandt for the kind assistance he has given in preparing slides for microscopic examination and in taking photomicrographs.

* Paper taken at the Paris Meeting of the Iron and Steel Institute, September, 1921.

† Colonel Belaiew, "Damascene Steel," *Journal of the Iron and Steel Institute*, 1918, No. I. page 417.

‡ "The Manufacture of High-Speed Steel in the Electric Furnace," by Rog. C. McKenna, President of the Vanadum-Alloy Steel Corporation. *Transactions of the American Electrochemical Society*; vol. xxxvii., page 322.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

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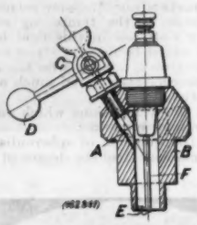
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

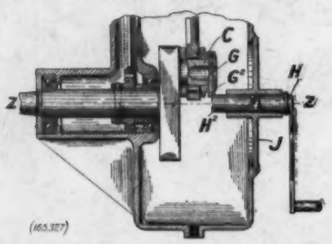
GAS ENGINES, PRODUCERS, HOLDERS, &c.

162,841. M. Macgregor, Dowanhill, Glasgow. Sparking Plugs. (1 *Fig.*) February 20, 1920.—A sparking plug for internal-combustion engines has a hole A right through to any



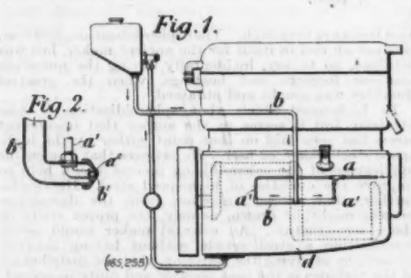
part of the centre of the plug into which is screwed a compression relief tap C. On opening the tap by the handle D, carbon that has accumulated on the electrodes is blown out through the tap by the pressure within the cylinder. (*Sealed.*)

165,327. J. F. Buckingham, Coventry. Crankshafts. (1 *Fig.*) June 18, 1920.—To provide means for applying a starting device to a crankshaft of the overhung or single web type, the crankpin C carries a bolt G which projects radially towards, and if necessary slightly beyond, the axis Z-Z of the crankshaft.



The head G² of the bolt G is adapted to be engaged by the dog H³ of the starting handle H, which is carried by the cover plate J on the crankcase. Thus the bolt G can be engaged, either at one side or on both sides of the axis of the crankshaft, by a starting dog, or starting dogs, on the starting handle. (*Accepted July* 6, 1921.)

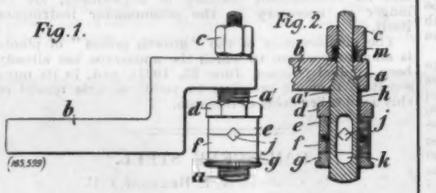
165,255. R. M. Alexander, Maidstone. Internal Combustion Engines. (2 *Figs.*) April 9, 1920.—The novel feature in this invention consists in introducing the lubricant to the working parts of an internal-combustion engine in the form of an atomised spray by means of lubricant ejecting nozzle having an air blast outlet nozzle disposed within the oil duct, the orifice of



the air blast outlet nozzle being in close proximity to that of the lubricant nozzle. Air under pressure is delivered to the pipe *a* from which it passes by way of the branch conduits *a*¹ to nozzles *a*², each disposed within an outer nozzle *b*¹ in connection with an oil conduit *b*. The nozzles *a*², *b*¹ project within the crank casing *d* and spray the oil on to the connecting rod and crankshaft bearings. (*Accepted July* 6, 1921.)

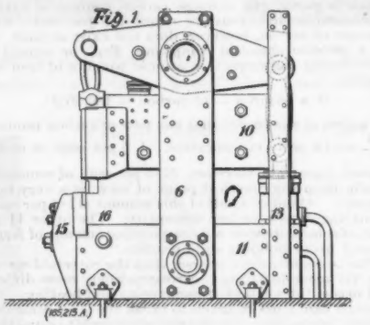
MACHINE AND OTHER TOOLS, SHAFTING, &c.

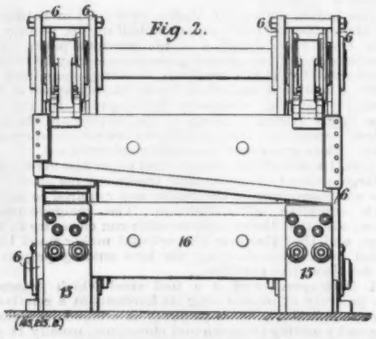
165,199. F. Layfield, Norton, Stockton-on-Tees, and G. P. Fairless, Stockton-on-Tees. Tool Holders. (2 *Figs.*) May 1, 1920.—The threaded spindle *a* is slotted to receive a tool which is angularly and longitudinally adjustable with regard to the tool bar *b*. The spindle *a* is mounted in a hole in one end of the tool bar and is screw-threaded on those portions which project above and below the tool bar. The threaded portion *a*¹ of the spindle *a* is provided with a hexagonal nut *d*, two adjacent loose sleeves *e*, *f*, and a milled nut *g*. The sleeves *e*, *f* are free to slide on the spindle and are prevented from rotation by means of keys engaging with a keyway *h* cut in the spindle. A V is cut in the adjacent faces of the sleeves so forming a diamond shaped hole *j* in which the cutting tool is fixed by screwing up the milled nut *g* and clamping the sleeves between the hexagonal nut and the milled nut. The hole corresponds with an elongated slot *k* in the spindle to allow the shank of the cutting tool to pass through



both sides of the sleeves and the spindle. A spiral spring *m* is mounted in an annular chamber in the nut *c* and around the spindle and bears on the tool bar *b*, so that when the nut *c* is slackened to adjust the angular position of the spindle the spring will hold the spindle up to the tool bar. (*Accepted July* 13, 1921.)

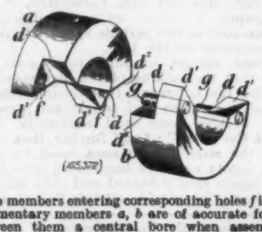
165,215. J. Crow, Biggar. Shearing Machines. (2 *Figs.*) March 24, 1920.—In shearing machines in which the frame is built entirely of rolled steel slabs, two of which carry the pivots of the rocking beam actuating the shear blade, the main stresses of the machine are taken by a series of links comprising rolled slabs connecting the base with the fulcrum of the rocking beam. The links are subject to direct tension only as distinguished from bending, shearing and other stresses which result





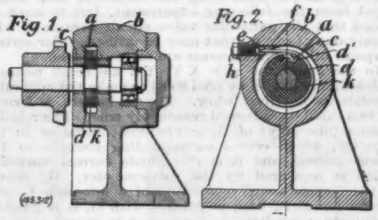
when unsymmetrically disposed plates are used to support the rocking beam. The fixed frame is built up entirely from rolled steel parts 6 and 13, which form the main vertical members, the rolled steel parts 10, 11 forming the main horizontal members and the members 15, 16 serving to brace the members 11 together. The main load due to shearing operations is taken by the member 6. Throughout the structure distance pieces and bolts are employed as required to keep the various members in proper relation and also to tie them together. (*Accepted July* 6, 1921.)

165,372. J. D. Thorburn, Selhurst. Shaft Couplings. (3 *Figs.*) October 28, 1920.—In shaft couplings of the kind comprising two complimentary members having the meeting ends thereof adapted to lap joint laterally with one another, the complementary members *a*, *b* are adapted, according to this invention, to be connected together at the lap joints by pins *g*



on one of the members entering corresponding holes *f* in the other. The complementary members *a*, *b* are of accurate formation to afford between them a central bore when assembled. The meeting ends of the members *a*, *b* are cut away at *d* and have oppositely inclined faces *d*¹, *d*² to constitute the lateral lap joint at diametrically opposite points of the collar, when the members *a*, *b* are in engagement. (*Accepted July* 6, 1921.)

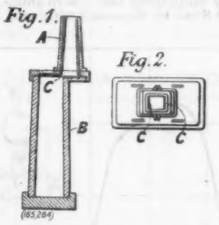
165,312. K. C. Appleyard, Birtley, W. E. Manners, Birtley, P. W. Bewicke, Newmarket, Sir J. F. Laycock, K.C.M.G., D.S.O., Bawtry, and M. R. Portal, Swansmore. Shaft Bearings. (2 *Figs.*) May 31, 1920.—The improvements are intended to prevent the exudation of lubricant from and the entrance of foreign matter into bearings. *a* is a channel in the housing *b* with holes in its side walls for the reception of a pin *c*. *d* is a flexible band of rectangular section shaped into a loop *d*¹ at



one end and attached at the other to a square shanked bolt *e* which passes through a hole *f* in the periphery of the channel *a*. The pin *c* passes through the loop *d*¹. The felt washer *k* is placed within the coil of the flexible band *d*. The felt washer *k* is adjustable by rotating the nut *h*. (*Accepted July* 6, 1921.)

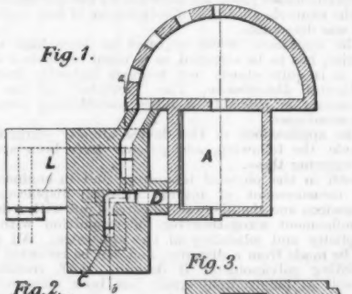
MINING, METALLURGY AND METAL-WORKING.

165,284. A. H. Dodgson, West Hartlepool, G. W. Trotter, West Hartlepool, and W. Dodgson, West Hartlepool. Casting Metals. (4 *Figs.*) April 30, 1920.—By the improvements according to this invention it is claimed to produce castings free from piping, blowholes or other flaws, whether due to contraction or otherwise, and also clean and free from foreign matter, including surface scum. According to the improvements, a "header" or "sprue" A is placed above the top of the mould B, having an outlet delivering into the mould close to the top edge



of the latter, the connecting passage C being constricted to form an elongated slot or rectangular gate. The header is lined with non-conducting and refractory material, and its dimensions are such as to ensure that metal is delivered uninterruptedly until the mould B is full. The metal in the header A remains molten for a longer time than the metal in the mould B and continues to feed into the casting while shrinking in the latter occurs, the column of molten metal being of sufficient height to feed the mould under pressure due to the head. (*Accepted July* 6, 1921.)

165,628. M. W. Travers, Highgate, London. Tank Furnaces. (2 *Figs.*) May 18, 1920.—Tank furnaces such as are used in the manufacture of glass are, according to this invention, provided on each side of the tank with an underfed gas producer C from which the gas passes through a short lead D into the back of the melting end of the tank A. A recuperator L is also pro-



vided on each side of the tank and from each, heated secondary air enters the lead D. The fuel beds are therefore brought very close to the inlet to the tank, and the loss of heat from the gas is reduced to a minimum. The recuperators L may be arranged alongside the producers C or underneath them, and are heated by the gases after they leave the working end of the tank. (*Accepted July* 13, 1921.)

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—The following appointments have been made in the Faculty of Engineering at University College: Mr. M. T. M. Ormsby (previously Reader in Surveying) to be Chadwick Professor in Municipal Engineering; Mr. Bernard H. Knight, to be Assistant in Municipal Engineering; Mr. H. T. Davidge, to be Senior Lecturer in Civil and Mechanical Engineering.